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The methodology of the FAO study: "Global Food Losses and Food Waste - extent, causes and prevention"- FAO, 2011

By SIK - The Swedish Institute for Food and Biotechnology

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Summary

In 2010, the Food and Agriculture Organization of the United Nations (FAO) commissioned the Swedish Institute for Food and Biotechnology (SIK) to carry out, from August 2010 to January 2011, two studies on food losses and waste, and in 2011 FAO published the report "*Global food losses and food waste - extent, causes and prevention*" (FAO 2011). The two studies focused on the extent and effects as well as causes and prevention of food losses and food waste, one for medium/high income countries and one for low income countries. The studies were carried out to serve as a basis for the international congress Save Food! arranged 16-17 May 2011.

This report aims to describe the full methodology used, in the two studies, to produce the results published in "*Global food losses and food waste – extent, causes and prevention"* (FAO 2011).

The studies quantified the volumes of food losses and food waste arising globally each year. *Food losses* refer to a decrease in food quantity or quality in the early stages of the food supply chain, reducing the amount of food suitable for human consumption. The concept food losses are thereby often related to post-harvest activities with lacking system or infrastructural capacities. *Food waste* on the other hand often refers to later stages of the food supply chain, such as retail and consumer households. Hence, the causes of food waste are often related to human behavior.

The medium and high income countries were grouped into the regions Europe; North America & Oceania and Industrialized Asia and the low income countries were grouped into Sub-Saharan Africa; North Africa, Western & Central Asia; South & Southeast Asia and Latin America. The commodity groups addressed were cereals; roots & tubers; oilseeds & pulses; fruit & vegetables; meat; fish & seafood and milk & eggs. The steps in the food supply chain addressed were agricultural production; postharvest handling & storage; processing & packaging; distribution and consumption.

The production volumes presented were collected from FAO Statistical Yearbook 2009. Waste percentages of losses and waste for different regions of the world; different commodity groups and different steps of the supply chain were collected from an extensive literature search. For quantifying losses and waste, national and regional Food Balance Sheets from the year 2007 were used, mapping out the regional food supplies. Different calculation models were applied for each commodity group; all calculations are exemplified in this report.

The methodology of the studies behind "*Global food losses and food waste – extent, causes and prevention*" is challenged by major data gaps for both waste percentages of losses and waste and the causes of losses and waste. The results must therefore be taken with great caution.

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1 Background

In 2011 the Food and Agriculture Organization of the United Nations (FAO) published the report "*Global food losses and food waste - extent, causes and prevention*" (FAO 2011), a publication based on two studies carried out from August 2010 to January 2011 by The Swedish Institute for Food and Biotechnology (SIK). The two studies were carried out on the extent and effects as well as causes and prevention of food losses and food waste, one for medium/high income countries and one for low income countries. The two studies highlight the food losses and waste occurring along food chains, and made assessments of the magnitude of these losses and waste, focussing on quantitative weight losses/waste. The studies compile, analyse and assemble data and reports produced on the topic of global food loss and waste during recent years. Where information was not available, assessments and assumptions were made.

The studies were carried out to serve as a basis for the international congress Save Food!, 16-17 May 2011, at the international packaging industry fair Interpack2011 in Düsseldorf, Germany. SaveFood! has been co-organized by Messe Düsseldorf and FAO and aims at awareness raising on global food losses and waste, and on the impact of these on poverty and hunger in the world, as well as on climate change and on the use of natural resources.

The FAO publication (FAO 2011) synthesize the main results from the studies and this report describes the full methodology used to produce the results, focusing on the quantitative results.

2 Aim

This study report aims to describe the methodology used for the studies behind the report "*Global food losses and food waste – extent, causes and prevention*" published by FAO, focusing on the quantitative results. The report describes the scope of the study; the data sources used and the calculation methods used for quantifying the magnitudes of losses and waste of each commodity group.

3 Description of methodology

3.1 Definitions

In the literature a distinction is often made between *food losses* and *food waste*. Both concepts are applied to lost and wasted food throughout the whole food supply chain; referred to as food that could have been used for human consumption. Hence, it does not apply to inedible food stuffs such as peels, and skin etc., which generally are not consumed. Losses and waste of meat is however reported in carcass weight (including bone). The idea was to report losses and waste of meat in carcass weight so that these volumes would be comparable to other volumes (e.g. production volumes), often reported in carcass weight.

Food losses refer to a decrease in food quantity or quality in the early stages of the food supply chain, before the food products reach their final stage, reducing the amount of food suitable for human consumption. The concept *food losses* are thereby often related to post-harvest activities with lacking system or infrastructural capacities (Parfitt, Barthel et al. 2010); it is not intentional.

Food waste on the other hand refers to the discarding of food products that are fit for consumption or fit to proceed in the food supply chain. This mostly occurs at later stages of the food supply chain, such as retail and consumer households. Hence, the causes of *food waste* are often related to human behavior and is intentionally (Parfitt, Barthel et al. 2010).

3.2 Scope

3.2.1 World regions

Medium and high income countries were divided into three world regions. All countries included in the medium and high income regions are listed in Table 1.

Table 1 Countries included in medium and high income regions

Europe		
Albania	Georgia	Netherlands
Armenia	Germany	Norway
Austria	Greece	Poland
Azerbaijan	Hungary	Portugal
Belarus	Iceland	Romania
Belgium	Ireland	Russian Federation
Bosnia & Herzegovina	Italy	Serbia
Bulgaria	Latvia	Slovakia
Croatia	Lithuania	Slovenia
Cyprus	Luxemburg	Spain
Czech Republic	Macedonia	Sweden
Denmark	Malta	Switzerland
Estonia	Moldova	Ukraine
Finland	Montenegro	United Kingdom
France		
North America & Oceania (NA&Oce)		**Industrialized Asia (Ind. Asia)**
Australia	USA	Japan
Canada		China
New Zealand		Republic of Korea

Low income countries were divided into four world regions. All countries included in the low income regions are listed in Table 2.

Table 2 Countries included in the low income regions

Sub-Saharan Africa (SSA)		**North Africa, Western & Central Asia (NA,WA&CA)**	**South & Southeast Asia (S&SE Asia)**	**Latin America (LA)**
Angola	Malawi	Algeria	Afghanistan	Argentina
Benin	Mali	Egypt	Bangladesh	Belize
Botswana	Mauritania	Islamic republic of Iraq	Bhutan	Bolivia
Burkina Faso	Mozambique	Israel	Cambodia	Brazil
Burundi	Namibia	Jordan	India	Chile
Cameroon	Niger	Kazakhstan	Indonesia	Colombia
Central African Republic	Nigeria	Kuwait	Iran	Costa Rica
Chad	Rwanda	Kyrgyzstan	Lao People's Democratic Republic	Cuba
Democratic Republic of the Congo	Senegal	Lebanon	Malaysia	Dominican Republic
Cote d'Ivoire	Sierra Leone	Libyan Arab Jamahiriya	Myanmar	Ecuador
Equatorial Guinea	Somalia	Mongolia	Nepal	El Salvador
Eritrea	South Africa	Morocco	Pakistan	Guatemala
Ethiopia	Sudan	Oman	Philippines	Guyana
Gabon	Swaziland	Saudi Arabia	Sri Lanka	Haiti
Gambia	United republic of Tanzania	Syrian Arab Republic	Thailand	Honduras
Ghana	Togo	Tajikistan	Vietnam	Jamaica
Guinea	Uganda	Tunisia		Mexico
Guinea-Bissau	Zambia	Turkey		Nicaragua
Kenya	Zimbabwe	Turkmenistan		Panama
Lesotho		United Arab Emirates		Paraguay
Liberia		Uzbekistan		Peru
		Yemen		Suriname
				Uruguay
				Venezuela

3.2.2 Commodity groups

Table 3 presents each commodity group addressed in the report. The commodities are grouped according to FAOSTAT's Food Balance Sheets (FBS) (FAO 2001), except milk and eggs for which there are separate FBS.

Table 3 Commodities included in each commodity group

Commodity group	Commodities included
Cereals (excl. beer)	Wheat, rice (milled), barley, maize, rye, oats, millet, sorghum, other cereals
Roots & Tubers	Potatoes, sweet potatoes, cassava, yams, other roots
Oilseeds & Pulses (incl. nuts)	Soybeans, groundnuts (shelled), sunflower seeds, rape and mustard seed, cottonseed, coconuts (incl. copra), sesame seed, palm kernels, olives, other oil crops
Fruit & Vegetables (incl. bananas)	Oranges and mandarins, lemons and limes, grapefruit, other citrus, bananas, plantains, apples (excl. cider), pineapples, dates, grapes (excl. wine), other fruit. Tomatoes, onions, other vegetables
Meat	Bovine meat, mutton/goat meat, pig meat, poultry meat, other meat, offals
Fish and seafood	Freshwater fish, demersal fish, pelagic fish, other marine fish, crustaceans, other mollusk, cephalopods, other aquatic products, aquatic mammal meat, other aquatic animals, aquatic plants
Milk and egg	The amount of milk available for human consumption as milk (but not as butter, cheese or any other milk product provided for separately in the FBS) and eggs

3.2.3 Food supply chain

When estimating food losses/waste in each step of the food supply chain, the following activities have been considered:

3.2.3.1 Vegetal products:

Agricultural production
Losses due to mechanical damage and/or spillage during harvest operation (e.g. threshing or fruit picking) and waste due to crops sorted out post-harvest etc.

Postharvest handling and storage
Losses include spillage and degradation during handling, storage and transportation between farm and distribution.

Processing and packaging
Include spillage and degradation during industrial or domestic processing, e.g. juice production, canning and bread baking. Losses and waste may occur when crops are sorted out if not suitable to process or during washing, peeling, slicing and boiling or during process interruptions or accidental spillage.

Distribution
Include losses and waste in the market system, at e.g. wholesale, supermarkets, retailers and wet markets.

Consumption
Include losses and waste during consumption at the household level.

3.2.3.2 Animal commodities:

Agricultural production
For bovine-, pork- and poultry meat, losses refer to animal death during breeding. For fish, losses refer to discards during fishing. For milk, losses refer to sickness (mastitis) for dairy cows.

Postharvest handling and storage
For bovine-, pork- and poultry meat, losses refer to death during transport to slaughter and condemnation at slaughterhouse. For fish, losses refer to spillage and degradation during icing, packaging, storage and transportation after landing. For milk, losses refer to spillage and degradation during transportation between farm and distribution.

Processing and packaging
For bovine-, pork- and poultry meat, losses refer to trimming spillage during slaughtering and additional industrial processing e.g. sausage production. For fish, losses refer to industrial processing such as canning or smoking. For milk, losses refer to spillage during industrial milk treatment (e.g. pasteurization) and milk processing to e.g. cheese and yoghurt.

Distribution
Include losses and waste in the market system, at e.g. wholesale, supermarkets, retailers and wet markets.

Consumption
Include losses and waste at the household level.

3.3 Data sources

3.3.1 Food volumes produced

The production volumes for all commodities (except for oil crops and pulses) were collected from the FAO Statistical Yearbook 2009 (FAO 2011). The production volumes for oil crops and pulses were collected from FAO’s FBS (FAOSTAT 2010).

The production volumes for each world region were compiled by summarizing the volumes produced of each commodity group for the countries included in each region according to Table 1 and Table 2. The production volumes were *not* used to quantify volumes of losses and waste in each region, see 3.3.3.

3.3.2 Weight percentages of food losses and waste

SIK has conducted a thorough literature search on the topic of global food losses and waste, focusing on weight percentages of losses and waste as well as on the causes of losses/waste and ways to prevent losses and waste. Data and publications have been sought in scientific journals, on the internet, in statistical databases as well as at national authorities, departments and NGOs. Several local FAO offices were contacted and asked to contribute valuable information. All information has been assessed on the basis of reliability and accuracy.

SIK also made use of its wide network of research colleges working in the field of sustainable food production. During the project, several researchers working with global food waste were contacted and asked to give input on the progressing work.

Where there are gaps of knowledge SIK has made own assumptions and estimations, based on food waste levels in comparable regions, commodity groups and/or steps of the food supply chain.

Annex 1 Waste percentages of food losses and waste describe all waste percentages used in the study.

3.3.3 Food Balance Sheets

When quantifying volumes of food lost and wasted in different regions of the world throughout the food supply chain, FBS from the year 2007 (FAOSTAT 2010) were used to examine the mass flows of each commodity group. A FBS shows the patterns of a country's food supply during a specific period of time. For each commodity group the domestic supply quantity (E) equals the sum of the supply elements production (A), import quantity (B), stock variations (C) and export quantity (D). Food available for human consumption (J) is left after withdrawing the utilization elements feed (F), seed (G), processing (H) and other utilities (I) from the domestic supply quantity (E) (FAO 2001) (Figure 1).

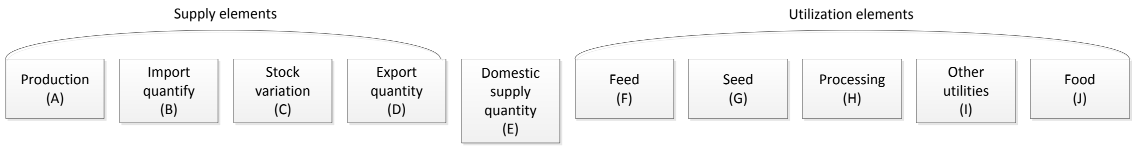

Figure 1 Model of the mass flows in a FBS.

More information about FBS can be found in "*Food Balance Sheets – A handbook*" (FAO 2001). Each step in the FBS was interpreted as follows:

Production (A)	Reported in primary crops for crops; carcass weight for meat; live weight equivalent for fish and total production leaving the manufacture for processed commodities.
Import quantity (B)	All movements of the commodity in question into the country/region.
Stock variation (C)	Changes in foremost government stocks.
Export quantity (D)	All movements of the commodity in question out of the country/region.
Domestic supply (E)	Sum of A, B, C, and D (of which D is negative).
Feed (F)	The amounts of the commodity in question used to feed animals.
Seed (G)	The amounts of the commodity in question used for reproductive purposes, e.g. seed, planting, eggs for hatching or fish for bait.
Processing (H)	The amount of the commodity available for human consumption as part of mixed processed food products, containing different types of commodities.
Other utilities (I)	The amounts of commodity lost during handling, storage and transport between production and distribution as well as amounts of the commodity used for non-food purposes, e.g. oil for oil production and wheat for bio-energy.
Food (J)	All forms of the commodity available for human consumption, e.g. wheat flour, vegetable oils etc. (although not including H).

All volumes in the FBS are reported in primary product or primary product equivalents.

FBS include estimates of postharvest losses during handling, storage and transports between farm and distribution (I, Figure 1). The FBS should not be considered altogether reliable. Many FBS suffer from data gaps, especially of utilization for feed, seed and manufacture. There are few reliable loss surveys available, therefore the estimations on postharvest loss volumes (I) were used in this study to calculate approximate loss percentages for the "postharvest handling and storage" stage in the food supply chain, according to the formula:

$$Losses/waste(\%)\ during\ postharvest\ handling\ and\ storage = \frac{I}{A+B+C}$$

Based on the world regions presented in Table 1 and Table 2, data on regional food supplies for each commodity group were collected and summarized from national or, when possible, regional FBS. Table 4 describes which FBS that was/were collected for each world region included in this study, the sum of FBS collected made up the region's food supply.

Table 4 National/regional FBS collected from FAOSTAT (FAOSTAT 2010) to summarize the food supply for each world region

World region:	Food Balance Sheets (2007) collected from FAOSTAT:
Europe	Europe
North America, Oceania	USA, Canada, Australia, New Zealand
Industrialized Asia	China, Japan, South Korea
Sub-Saharan Africa	Western Africa; Southern Africa; Middle Africa; Eastern Africa
North Africa, West & Central Asia	North Africa; Western Asia; Central Asia; Mongolia
South & Southeast Asia	Southern Asia; Southeastern Asia
Latin America	Central America; South America; Caribbean

3.4 Calculations

Data from national/regional FBS, together with the weight percentages of food losses/waste, were used to quantify the volumes of losses and waste for each region and commodity group separately (according to Table 3 and Table 4). The calculations were made in excel-sheets, one for each region and commodity/commodity group respectively. For information on conversion factors and allocation factors applied to quantify loss/waste volumes, as well as the assumed proportions of crops utilized fresh and processed in each region of the world, see Annex 2 Additional references for quantifying food losses/waste.

Below follows a description of how the mass flows of each commodity group were considered, as well as detailed descriptions on how losses and waste were quantified for each step of the food supply chain. The data shown in Figure 2-Figure 10 are collected from FBS according to Table 4. The descriptions are exemplified by the calculations made for Europe.

3.4.1 Cereals

In the FBS, cereals are reported as primary product or primary product equivalents, the exception is rice which is reported as milled equivalents. Losses and waste were quantified separately for different types of cereals (“wheat+rye”; “oats+barley+other cereals”; “maize”; “rice” and “millet+sorghum”), and thereafter added together for total cereal losses and waste.

The calculations of losses and waste are exemplified by the calculations for “wheat + rye” in Europe. Figure 2 shows how the mass flows (1000 tonnes) of “wheat + rye” were considered.

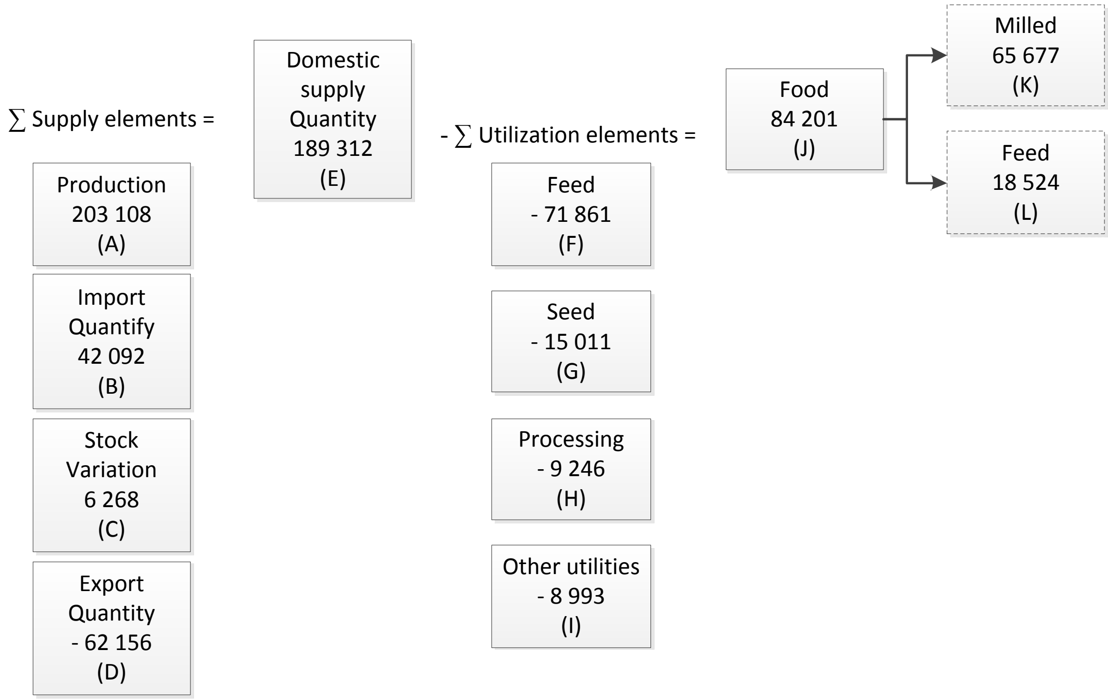

Figure 2 Model of the mass flows of wheat and rye in Europe, derived from FAO’s FBS 2007 presented in 3.3.3. The domestic supply quantity (E) equals the sum of the supply elements production (A), import quantity (B), stock variations (C) and export quantity (D). Food (available for human consumption) (J) is left after withdrawing the utilization elements feed (F), seed (G), processing (H) and other utilities (I) from the domestic supply quantity (E). Boxes with dotted lines were calculated using conversion factors presented in Annex 2 Additional references for quantifying food losses/waste. In total, food available for human consumption was considered as H+K.

Conversion factors were used (except for rice) to convert food available for human consumption (J) to milled equivalents (K). The feed (L) amount was derived from subtracting the milled equivalents (K) from Food (J). Conversion factors used for all types of cereal in Europe (Wirsenius 2000):

Wheat + rye	0.78
Rice	1
Maize	0.69
Millet + sorghum	0.69
Oats + barley + other	0.78

Allocation factors were used to estimate the fraction of cereals, lost during agricultural production and postharvest handling and storage, which make up cereals lost for human consumption. One allocation factor was used for each region of the world, for all cereal types. The allocation factors were used since a large share of the cereal domestic supply (E) is used for feed and/or bio energy. In the example of wheat and rye in Europe, 35% of the cereal domestic supply (E) is used for human consumption (K), therefore 35% of losses during agricultural production and postharvest activities were considered cereals lost for human consumption.

The loss percentage during postharvest handling and storage was assumed I/(A+B+C), for the total cereal mass flows (1000 tonnes) in Europe including all types of cereal, according to the interpretation of the FBS described in 3.3.3:

$$\frac{17\,774(I)}{390\,587(A) + 87\,780(B) + 14\,197(C)} = 4\ \%$$

Table 5 presents the loss/waste percentages used for calculating losses and waste of all types of cereals in Europe, references can be found in Annex 1 Waste percentages of food losses and waste. Table 6 presents the calculations made for quantifying losses and waste in each step of the supply chain.

Table 5 Waste percentages used for cereals in Europe, references can be found in Annex 1 Waste percentages of food losses and waste.

Agricultural production	Postharvest handling and storage	Processing and packaging	Distribution	Consumption
2 %	4 %	Milling 0.5% Processed 10%	2%	25%

Table 6 Calculations of losses and waste (1000 tonnes) for wheat + rye in Europe, taking into account the loss/waste percentages in Table 5 and the conversion factors and allocation factors in Annex 2 Additional references for quantifying food losses/waste

Step	Calculations
Agricultural production	Losses/waste was calculated as having occurred *before* the production volume (A) was derived. $\frac{0{,}02}{1 - 0{,}02} \times 203\,108(A) = 4\,145$ $allocation\ factor: 4\,145 \times 0{,}35 = 1\,451$
Postharvest handing & storage	$0{,}04 \times 203\,108(A) = 7\,329$ $allocation\ factor: 7\,329 \times 0{,}35 = 2\,565$
Processing & packaging	$milling: 0{,}005 \times 84\,201(J) = 421$ $industrial\ bread\ baking:$ $(65\,677(K) + 9\,246(H) - 421) \times 0{,}1 = 7\,450$ $total\ processing\ \&\ packaging: 421 + 7\,450 = 7\,871$
Distribution	$(65\,677(\mathrm{K}) + 9\,246(\mathrm{H}) - 421 - 7\,450) \times 0{,}02 = 1\,341$
Consumption	$(65\,677(K) + 9\,246(H) - 421 - 7\,450 - 1\,341) \times 0{,}25) = 16\,428$

3.4.2 Roots and tubers

Food available for human consumption (J) was separated into fresh (K) and processed (L) roots & tubers (r&t). The proportion utilized fresh in each region can be found in Annex 2 Additional references for quantifying food losses/waste. Different waste estimates were applied to fresh and processed roots & tubers at the distribution and consumption levels respectively.

Figure 3 shows how the mass flows (1000 tonnes) of roots & tubers were considered.

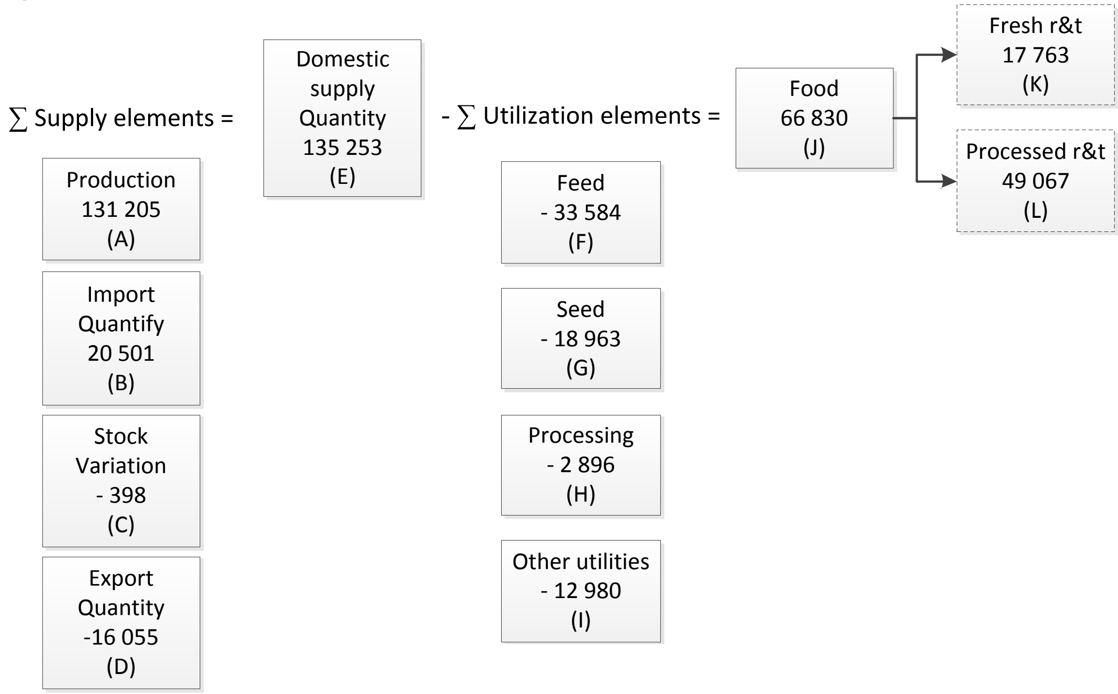

Figure 3 Model of the mass flows of roots & tubers in Europe, derived from FAO's FBS 2007 presented in 3.3.3. The domestic supply quantity (E) equals the sum of the supply elements production (A), import quantity (B), stock variations (C) and export quantity (D). Food (available for human consumption) (J) is left after withdrawing the utilization elements feed (F), seed (G), processing (H) and other utilities (I) from the domestic supply quantity (E). Boxes with dotted lines were calculated using factors presented in Annex 2 Additional references for quantifying food losses/waste. In total, food available for human consumption was considered as H+K+L.

Conversions factors were used to estimate the fraction of primary product volumes which is edible. One conversion factor was used for industrial peeling, one for peeling by hand and one as a mean of the two:

Industrial peeling	0.90
Peeling by hand	0.74
Mean value	0.82

The loss percentage during postharvest handling and storage was assumed I/(A+B+C), for total mass flows of roots & tubers in Europe according to the interpretation of the FBS described in 3.3.3:

$$\frac{12\ 980(I)}{131\ 205(A) + 20\ 501(B) - 398(C)} = 9\ \%$$

Table 7 presents the loss/waste percentages used for calculating losses and waste of roots & tubers in Europe, references can be found in Annex 1 Waste percentages of food losses and waste. Table 8 presents the calculations made for quantifying losses and waste in each step of the supply chain.

Table 7 Waste percentages used for roots & tubers in Europe, references can be found in Annex 1 Waste percentages of food losses and waste.

Agricultural production	Postharvest handling and storage	Processing and packaging	Distribution	Consumption
20 %	9 %	15%	Fresh 7% Processed 3%	Fresh 17% Processed 12%

Table 8 Calculations of losses and waste (1000 tonnes) for roots & tubers in Europe, taking into account the loss/waste percentages in Table 7; the proportion utilized fresh and the conversion factors presented in Annex 2 Additional references for quantifying food losses/waste

Step	Calculations
Agricultural production	Losses/waste was calculated as having occurred *before* the production volume (A) was derived. $\frac{0,2}{1-0,2} \times 131\,205(A) = 32\,801$ $conversion\ factor: 32\,801 \times 0,82 = 26\,897$
Postharvest handing & storage	$0,09 \times 131\,205(A) = 11\,255$ $conversion\ factor: 11\,255 \times 0,82 = 9\,229$
Processing & packaging	$0,15 \times (2\,896(H) + 49\,067(L)) = 7\,794$ $conversion\ factor: 7\,794 \times 0,9 = 7\,015$
Distribution	$processed: 0,03 \times (2\,896(H) + 49\,067(L) - 7\,794) = 1\,325$ $conversion\ factor: 1\,325 \times 0,9 = 1\,193$ $fresh: 0,07 \times 17\,763(K) = 1\,243$ $conversion\ factor: 1\,243 \times 0,74 = 920$ $total\ distribution: 1\,193 + 920 = 2\,113$
Consumption	$processed:$ $0,12 \times (2\,896(H) + 49\,067(L) - 7\,794 - 1\,325) = 5\,141$ $conversion\ factor: 5\,141 \times 0,9 = 4\,627$ $fresh: 0,17 \times (17\,763(K) - 1\,243) = 2\,808$ $conversion\ factor: 2\,808 \times 0,74 = 2\,078$ $total\ consumption: 4\,627 + 2\,078 = 6\,705$

3.4.3 Oilseeds and pulses

Losses and waste of oilseeds and pulses were first calculated separately and then added together for total results presented in 3.4.8.

Oil seeds aimed for human consumption mainly consists of extracted oils. Therefore, FBS for both oil crops and vegetable oils were used to quantify losses and waste from oil seeds. Figure 4 shows how the mass flows (1000 tonnes) of oil crops and vegetable oils were considered. The utilization elements “food” and “processing” for vegetable oils and “food” for oil crops were considered the oilseeds utilized for human consumption, including raw material and extracted oil together.

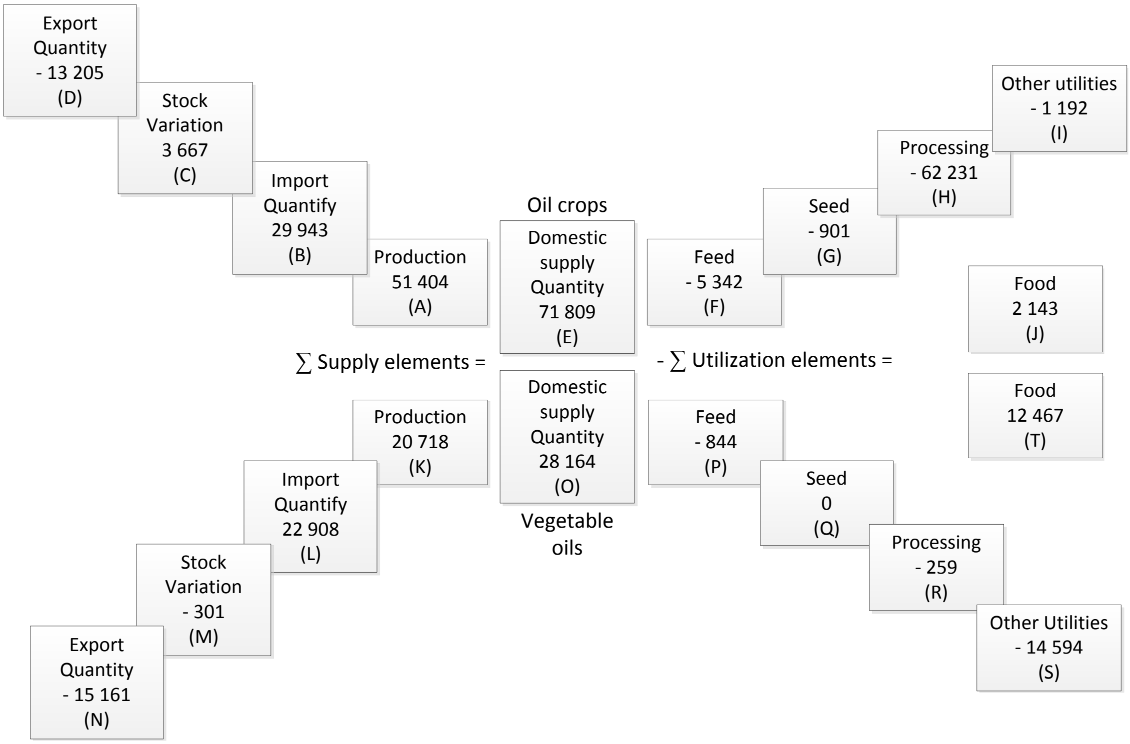

Figure 4 Model of the mass flows of oil crops and vegetable oils in Europe, derived from FAO’s FBS 2007 presented in 3.3.3. For oil crops, the domestic supply quantity (E) equals the sum of the supply elements production (A), import quantity (B), stock variations (C) and export quantity (D). Food (available for human consumption) (J) is left after withdrawing the utilization elements feed (F), seed (G), processing (H) and other utilities (I) from the domestic supply quantity (E). For vegetable oils, the domestic supply quantity (O) equals the sum of the supply elements production (K), import quantity (L), stock variations (M) and export quantity (N). Food (available for human consumption) (T) is left after withdrawing the utilization elements feed (P), seed (Q), processing (R) and other utilities (S) from the domestic supply quantity (O). In total, food available for human consumption was considered as J+T+R.

Allocation factors were used to estimate the fraction of oil crops, lost during agricultural production and postharvest handling and storage which make up oil crops lost for human consumption. Different allocation factors were used for different world regions. The allocation factors were used since a large share of the oil crop domestic supply (E) is used for feed, seed, bio-energy and soap production. In the example of oil crops in Europe, 20% of the oil crop domestic supply (E) is used for human consumption (J+T), therefore 20% of losses during agricultural production and postharvest activities were considered oil crops lost for human consumption.

The loss percentage during postharvest handling and storage for oilseeds and pulses was assumed I/(A+B+C), for total mass flows of oil crops in Europe according to the interpretation of the FBS described in 3.3.3. In other words, the estimate of percentage losses of oil crops during postharvest handling and storage was used as a generalization for losses during postharvest handling and storage for the commodity group oilseeds and pulses:

$$\frac{1\,192(I)}{51\,404(A) + 29\,943(B) + 3\,667(C)} = 1\,\%$$

Table 9 shows the waste percentages used for calculating losses and waste of oilseeds in Europe, references can be found in Annex 1 Waste percentages of food losses and waste. Table 10 presents the calculations made for quantifying losses and waste in each step of the supply chain.

Table 9 Waste percentages used for oilseeds in Europe, references can be found in Annex 1 Waste percentages of food losses and waste.

Agricultural production	**Postharvest handling and storage**	**Processing and packaging**	**Distribution**	**Consumption**
10 %	1 %	5%	1%	4%

Table 10 Calculations of losses and waste (1000 tonnes) for oilseeds in Europe, taking into account the loss/waste percentages in Table 9 and the allocation factors presented in Annex 2 Additional references for quantifying food losses/waste

Step	**Calculations**
Agricultural production	Losses/waste was calculated as having occurred *before* the production volume (K) was derived. $oil\ crops\colon \frac{0{,}1}{1-0{,}1} \times 51\,404(A) = 5\,712$ $allocation\ factor\colon\ 5\,712 \times 0{,}2 = 1\,142$
Postharvest handing & storage	$oil\ crops\colon 0{,}01 \times 51\,404(A) = 721$ $allocation\ factor\colon 721 \times 0{,}2 = 144$
Processing & packaging	$vegetable\ oil\colon$ $(0{,}05 \times 259(R)) + ((\frac{0.05}{1-0.05}) \times 12\,467(T)) = 669$
Distribution	$vegetable\ oil\colon$ $0{,}01 \times (2\,143(J) + 12\,467(T) + 259(R) - 669) = 142$
Consumption	$vegetable\ oil\colon$ $0{,}04 \times (2\,143(J) + 12\,467(T) + 259(R) - 669 - 142) = 562$

Figure 5 shows how the mass flows (1000 tonnes) of pulses were considered.

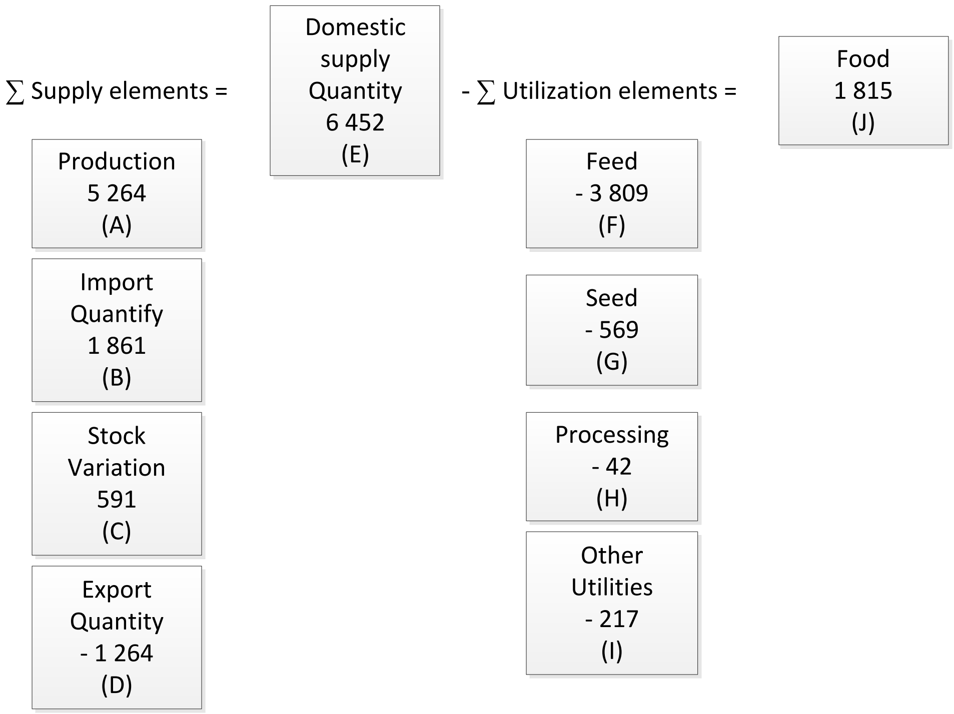

Figure 5 Model of the mass flows of pulses in Europe, derived from FAO's FBS 2007 presented in 3.3.3. The domestic supply quantity (E) equals the sum of the supply elements production (A), import quantity (B), stock variations (C) and export quantity (D). Food (available for human consumption) (J) is left after withdrawing the utilization elements feed (F), seed (G), processing (H) and other utilities (I) from the domestic supply quantity (E). In total, food available for human consumption was considered as H+J.

Table 11 presents the loss/waste percentages used for calculating losses and waste of pulses in Europe, references can be found in Annex 1 Waste percentages of food losses and waste. Table 12 presents the calculations made for calculating losses and waste in each step of the supply chain.

Table 11 Waste percentages used for pulses in Europe, references can be found in Annex 1 Waste percentages of food losses and waste.

Agricultural production	Postharvest handling and storage	Processing and packaging	Distribution	Consumption
10 %	1 %	5%	1%	4%

Table 12 Calculations of losses and waste (1000 tonnes) for pulses in Europe, taking into account the loss/waste percentages presented in Table 11

Step	Calculations
Agricultural production	Losses/waste was calculated as having occurred *before* the production volume (A) was derived. $\frac{0,1}{1-0,1} \times 5\,264(A) = 585$
Postharvest handing & storage	$0,01 \times 5\,264(A) = 74$
Processing & packaging	$0,05 \times 42(H) = 2$
Distribution	$0,01 \times (42(H) + 1\,815(J) - 2) = 19$
Consumption	$0.04 \times (42(H) + 1\,815(J) - 2 - 19) = 73$

3.4.4 Fruit and vegetables

Food available for human consumption (J) was separated into fresh (K) and processed (L) fruit and vegetables (f&v). The proportion utilized fresh in each region can be found in Annex 2 Additional references for quantifying food losses/waste. Different waste estimates were applied to fresh and processed fruit & vegetables at the distribution and the consumption levels respectively.

Figure 6 shows how the mass flows (1000 tonnes) of fruit & vegetables were considered.

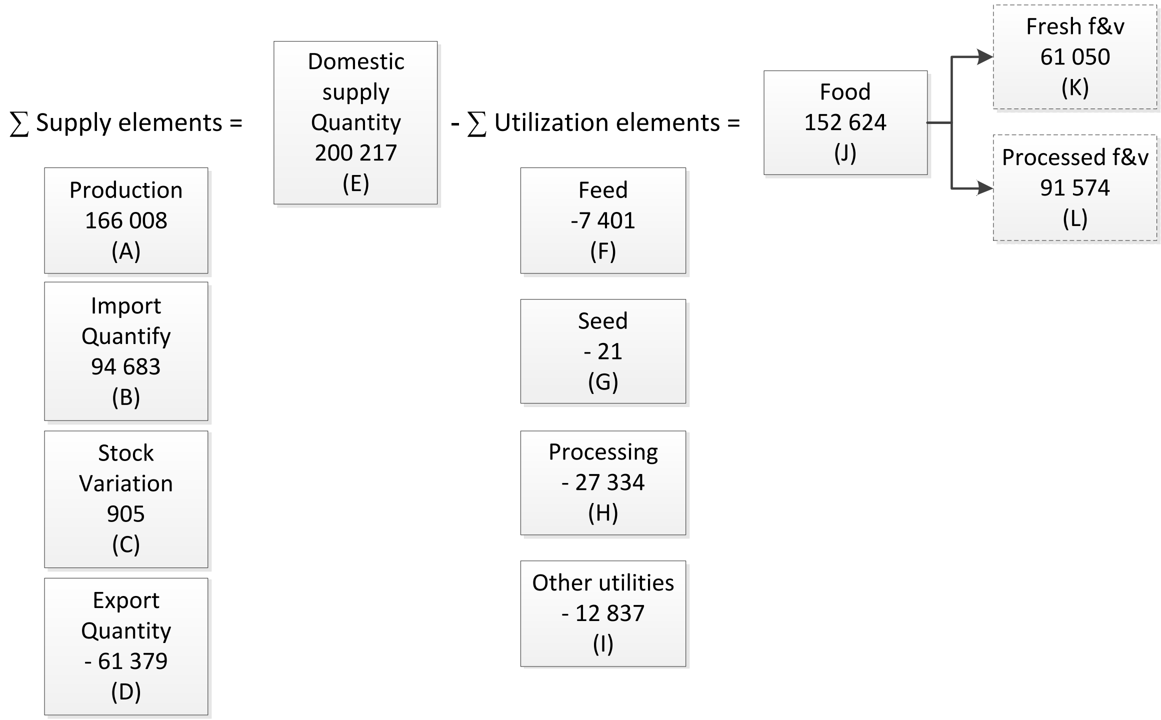

Figure 6 Model of the mass flows of fruit & vegetables in Europe, derived from FAO's FBS 2007 presented in 3.3.3. The domestic supply quantity (E) equals the sum of the supply elements production (A), import quantity (B), stock variations (C) and export quantity (D). Food (available for human consumption) (J) is left after withdrawing the utilization elements feed (F), seed (G), processing (H) and other utilities (I) from the domestic supply quantity (E). Boxes with dotted lines were calculated using factors presented in Annex 2 Additional references for quantifying food losses/waste. In total, food available for human consumption was considered as H+K+L.

Conversions factors were used to estimate the fraction of primary product volumes which is edible. One conversion factor was used for industrial peeling, one for peeling by hand and one as a mean of the two:

Industrial peeling	0.75
Peeling by hand	0.8
Mean value	0.77

The loss percentage during postharvest handling and storage was assumed I/(A+B+C), for total mass flows of fruit & vegetables in Europe according to the interpretation of the FBS described in 3.3.3:

$$\frac{12\,837(H)}{166\,008(A) + 94\,683(B) + 905(C)} = 10\%$$

Table 13 presents the loss/waste percentages used for calculating losses and waste of fruit & vegetables in Europe, references can be found in Annex 1 Waste percentages of food losses and waste. Table 14 presents the calculations made for quantifying losses and waste in each step of the supply chain.

Table 13 Waste percentages used for fruits & vegetables in Europe, references can be found in Annex 1 Waste percentages of food losses and waste.

Agricultural production	Postharvest handling and storage	Processing and packaging	Distribution	Consumption
20 %	5 %	2%	Fresh 10% Processed 2%	Fresh 19% Processed 15%

Table 14 Calculations of losses and waste (1000 tonnes) for fruit & vegetables in Europe, taking into account the loss/waste percentages in Table 13; the proportion utilized fresh and the conversion factors presented in Annex 2 Additional references for quantifying food losses/waste

Step	Calculations
Agricultural production	Losses/waste was calculated as having occurred *before* the production volume (A) was derived. $\frac{0,2}{1-0,2} \times 166\,008(A) = 41\,502$ $conversion\ factor: 41\,502 \times 0,77\ = 31\,957$
Postharvest handing & storage	$0,05\ \times 166\,008(A)\ = 8\,146$ $conversion\ factor: 8\,146\ \times 0,77\ = 6\,273$
Processing & packaging	$0,02\ \times (27\,334(H) + 91\,574(L)) = 2\,378$ $conversion\ factor: 2\,378\ \times 0,75\ = 1\,784$
Distribution	$processed =\ 0,02\ \times\ (27\,334(H) + 91\,574(L) - 2\,378) = 2\,331$ $conversion\ factor: 2\,331\ \times 0,75\ = 1\,748$ $fresh = 0,1\ \times\ 61\,050(K) = 6\,105$ $conversion\ factor: 6\,105\ \times 0,8\ = 4\,884$ $total\ distribution; 1\,748 + 4\,884 = 6\,632$
Consumption	$processed:$ $0,15\ \times\ (27\,334(H) + 91\,574(L) - 2\,378 - 2\,331) = 17\,130$ $conversion\ factor: 17\,130\ \times 0,75\ = 12\,875$ $fresh: 0,19\ \times (61\,050(K) - 6\,105) = 10\,439$ $conversion\ factor: 10\,439\ \times 0,8\ = 8\,352$ $total\ consumption: 12\,875 + 8\,352 = 21\,227$

3.4.5 Meat

Losses during agricultural production refer to animal mortality during breeding. Losses during postharvest handling and storage refer to the animal mortality during transportation to slaughter and animals rejected at slaughterhouse. All three types of losses were calculated separately for each type of meat produced (cattle, pig, chicken, duck, turkey, goat, sheep and lamb etc.). First, production volumes were converted into number of animal heads. Second, losses were calculated as animal heads lost during rejection at slaughterhouse, transportation to slaughter and during breeding. Third, animal heads lost were converted to carcass weight.

Figure 7 shows how the mass flows (1000 tonnes, carcass weight) of meat were considered.

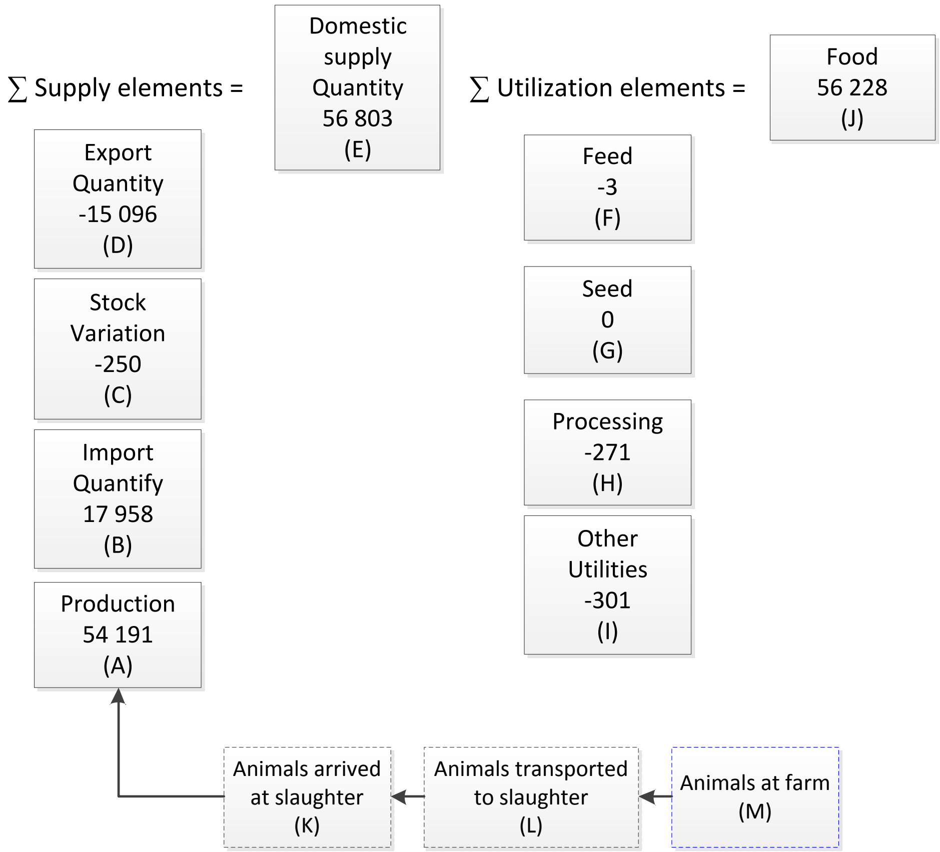

Figure 7 Model of the mass flows of meat in Europe, derived from FAO's FBS 2007 presented in 3.3.3. The domestic supply quantity (E) equals the sum of the supply elements production (A), import quantity (B), stock variations (C) and export quantity (D). Food (available for human consumption) (J) is left after withdrawing the utilization elements feed (F), seed (G), processing (H) and other utilities (I) from the domestic supply quantity (E). Boxes with dotted lines refer to number of animal heads arrived at slaughter (K); transported to slaughter (L) and bred at farm (M) and were calculated using the loss percentages presented in Table 15 for rejection at slaughter (K); mortality during transport to slaughter (L) and mortality during breeding (M). In total, food available for human consumption was considered as H+J.

Table 15 shows the loss/waste percentages used for calculating losses and waste of different types of meat in Europe. References can be found in Annex 1 Waste percentages of food losses and waste.

Table 15 Different loss/waste percentages used for different types of meat (pig meat; chicken meat; cattle meat; turkey meat and sheep meat) in Europe, references can be found in Annex 1 Waste percentages of food losses and waste. Loss/waste percentages for agricultural production and postharvest handling and storage are weighted averages from the loss/waste percentages for the different meat types.

	Average for meat	Pig meat	Chicken meat	Cattle meat	Turkey meat	Sheep meat
Agricultural production	*3.2% (weighted)*					
Mortality during breeding		2.5%	4%	2.25%	10%	10%
Postharvest handling and storage	*0.7% (weighted)*					
Mortality during transport to slaughter		0.11%	0.35%	0.013%	0.38%	0.018%
Rejection at slaughter		0.12%	1.3%	0.6%	1.5%	0.6%
Processing	5%					
Distribution	4%					
Consumption	11%					

First, the 2007 production volumes (1000 tonnes, carcass weight) and slaughtered animals (heads) for the main types of livestock were collected from FAOSTAT (FAOSTAT 2010). To check that the main livestock flows were covered; the sum total 52 516 was compared to the total production volume (54 191), derived from the 2007 Food Balance Sheet for Europe.

Table 16 Production volumes (tonnes carcass weight) and slaughtered animals (heads) for the main livestock flows (pig meat; chicken meat; cattle meat; turkey meat and sheep meat) in Europe 2007, collected from FAOSTAT (FAOSTAT 2010); CW/head is calculated from the collected production volumes and slaughtered animals; CW =carcass weight

Livestock	Production (1000 tonnes CW)	Slaughtered (head)	CW/head (kg)
Pig meat	26 750	304 993 750	88
Chicken meat	11 731	7 761 050 000	1,5
Cattle meat	11 146	46 203 194	241
Turkey meat	1 643	224 778 000	7,3
Sheep meat	1 246	83 688 693	15
Total	52 516		

Together with the corresponding waste percentages, the number of heads produced was used to calculate losses during agricultural production (mortality during breeding) and postharvest handling and storage (mortality during transportation to slaughter & rejection at slaughterhouse) in the following order:

1. Losses due to rejection at slaughterhouse
2. Losses due to animal mortality during transportation to slaughter
3. Losses due to animal mortality during breeding

Losses were quantified as having occurred before the production volume (A) was derived, according to Figure 7. In the example of pig meat:

$$rejection\ at\ slaughter: \frac{0{,}0012}{1-0{,}0012} \times 304\ 993\ 750 = 366\ 432$$

$$transportation\ to\ slaughter: \frac{0{,}0011}{1-0{,}0011} \times (304\ 993\ 750 + 366\ 432) = 336\ 266$$

$$during\ breeding: \frac{0{,}025}{1-0{,}025} \times (304\ 993\ 750 + 366\ 432 + 336\ 266) = 7\ 838\ 370$$

For all types of livestock, these calculations resulted in the amounts presented in Table 17.

Table 17 Summary of losses (heads & 1000 tonnes carcass weight) due to rejection at slaughter; transportation to slaughter and mortality during breeding, for the main types of livestock in Europe (pig meat; chicken meat; cattle meat; turkey meat and sheep meat); CW=carcass weight

	Rejection at slaughter		**Transportation to slaughter**		**During breeding**	
Livestock	Heads	CW	Heads	CW	Heads	CW
Pig meat	366 432	32	336 266	29	7 838 370	687
Chicken meat	102 222 543	153	27 618 117	41	328 787 111	493
Cattle meat	278 893	67	6 043	1,5	1 070 059	258
Turkey meat	3 423 015	25	870 472	6	25 452 387	186
Sheep meat	505 163	8	15 158	0,2	9 356 557	140
Total		285		79		1 765

The weighted average waste percentages for agricultural production (3.2%) and postharvest handling and storage (0.7%) were calculated from the lost production volumes (Table 17) and the total production (Table 16):

$$weighted\ waste\ \%\ agricultural\ production = \frac{1\,765}{52\,516 + 1\,765} = 3.2\%$$

$$weighted\ waste\ \%\ postharvest\ handling\ and\ storage = \frac{79 + 285}{52\,516 + 79 + 285} = 0.7\%$$

Table 18 Calculations of losses and waste (1000 tonnes) for total meat in Europe, taking into account the loss/waste percentages in Annex 1 Waste percentages of food losses and waste. Volumes make up carcass weight; no conversion factors were used to calculate edible parts (not including bones)

Step	**Calculations**
Agricultural production	1 764 (Table 17)
Postharvest handing & storage	285 + 79 = 364 (Table 17)
Processing & packaging	$0{,}05 \times (271(H) + 56\,228(J)) = 2\,825$
Distribution	$0{,}04 \times (271(H) + 56\,228(J) - 2\,825) = 2\,147$
Consumption	$0{,}11 \times (271(H) + 56\,228(J) - 2\,825 - 2\,147) = 5\,668$

3.4.6 Fish and seafood

Food available for human consumption (J) was separated into fresh (K) and processed (L) fish and seafood (f&s). The proportion utilized as fresh can be found in Annex 2 Additional references for quantifying food losses/waste. Different waste estimates were applied to fresh and processed fish & seafood at the distribution and the consumption levels respectively. Figure 8 shows how the mass flows of fish & seafood in Europe were considered.

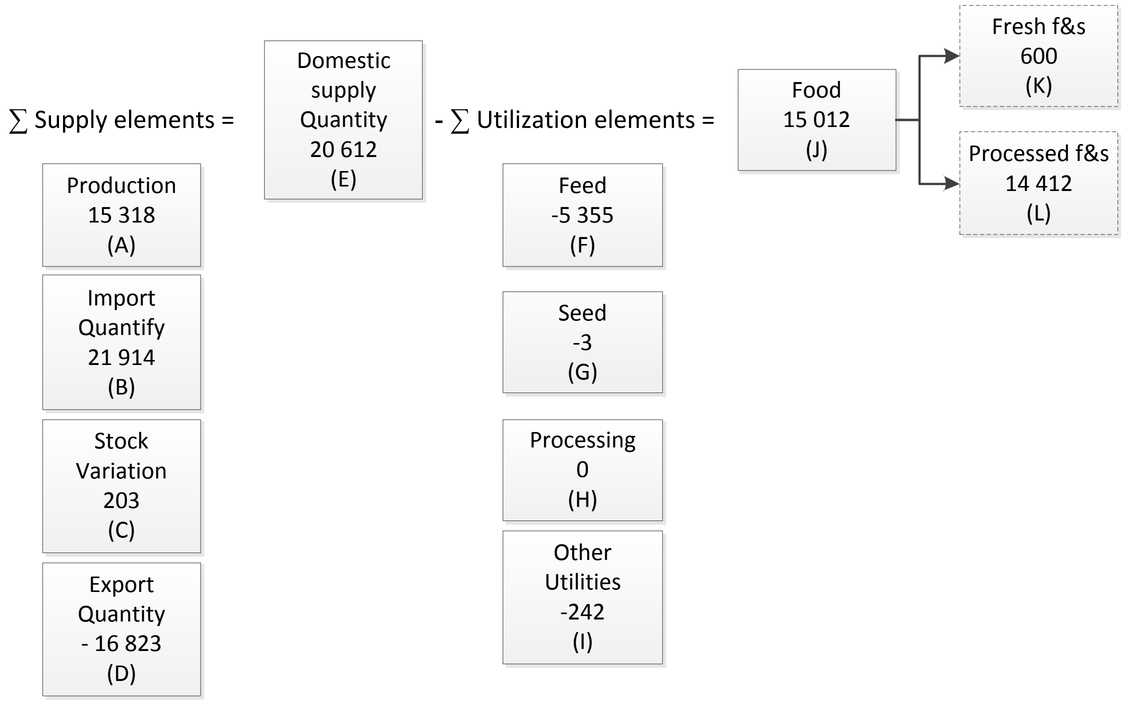

Figure 8 Model of the mass flow of fish & seafood in Europe, derived from FAO's FBS 2007 presented in 3.3.3. The domestic supply quantity (E) equals the sum of the supply elements production (A), import quantity (B), stock variations (C) and export quantity (D). Food (available for human consumption) (J) is left after withdrawing the utilization elements feed (F), seed (G), processing (H) and other utilities (I) from the domestic supply quantity (E). Boxes with dotted lines were calculated using factors presented in Annex 2 Additional references for quantifying food losses/waste. In total, food available for human consumption was considered as H+K+L.

A conversions factor was used to estimate the fraction of primary product volumes which is edible. The average yield in edible weight per wet weight of the 99 most important fish species is 55% and a median value of 54% ranging from 36% to 67% (FAO 1989). In relation to the average commercial species it is reasonable to believe that the average by catch, often consisting of juvenile species should be lower than the average. However, without a suitable dataset we have assumed a conservative arbitrary value of a 0.5 conversion factor for general by catch. That is, we assumed that 50% of the mass discarded at sea could be used for human consumption.

Table 19 presents the loss/waste percentages used for calculating losses and waste of fish & seafood in Europe, references can be found in Annex 1 Waste percentages of food losses and waste. Table 20 presents the calculations made for quantifying losses and waste in each step of the supply chain.

Table 19 Waste percentages used for fish & seafood in Europe, references can be found in Annex 1 Waste percentages of food losses and waste.

Agricultural production	Postharvest handling and storage	Processing and packaging	Distribution	Consumption
9.4%	0.5 %	6%	Fresh 9% Processed 5%	Fresh 11% Processed 10%

Table 20 Calculations of losses and waste (1000 tonnes) for fish & seafood in Europe, taking into account the loss/waste percentages in Table 19 and Annex 3 Discards as potential human consumption as well as the proportion utilized fresh and the conversion factors presented in Annex 2 Additional references for quantifying food losses/waste

Step	Calculations
Agricultural production	1 110 Calculation explained in Annex 3 Discards as potential human consumption. $conversion\ factor: 1\,110 \times 0.5 = 555$
Postharvest handing & storage	$0{,}005 \times 15\,318(A) = 77$ $conversion\ factor: 77 \times 0.5 = 38$
Processing & packaging	$0{,}06 \times (0(H) + 14\,412(L)) = 865$ $conversion\ factor: 865 \times 0.5 = 432$
Distribution	$processed = 0{,}05 \times (0(H) + 14\,412(L) - 865) = 677$ $conversion\ factor: 677 \times 0.5 = 339$ $fresh = 0{,}09 \times 600(K) = 54$ $conversion\ factor: 54 \times 0.5 = 27$ $total\ distribution: 339 + 27 = 366$
Consumption	$processed = 0.1 \times (0(H) + 14\,412(L) - 865 - 677) = 1\,287$ $conversion\ factor: 1\,287 \times 0.5 = 644$ $fresh = 0{,}11 \times (600(K) - 54) = 60$ $conversion\ factor: 60 \times 0.5 = 30$ $total\ consumption: 644 + 30 = 674$

3.4.7 Milk and egg

Losses and waste of milk and eggs were first calculated separately and then added together for total results presented in 3.4.8.

Figure 9 shows how the mass flows of milk were considered.

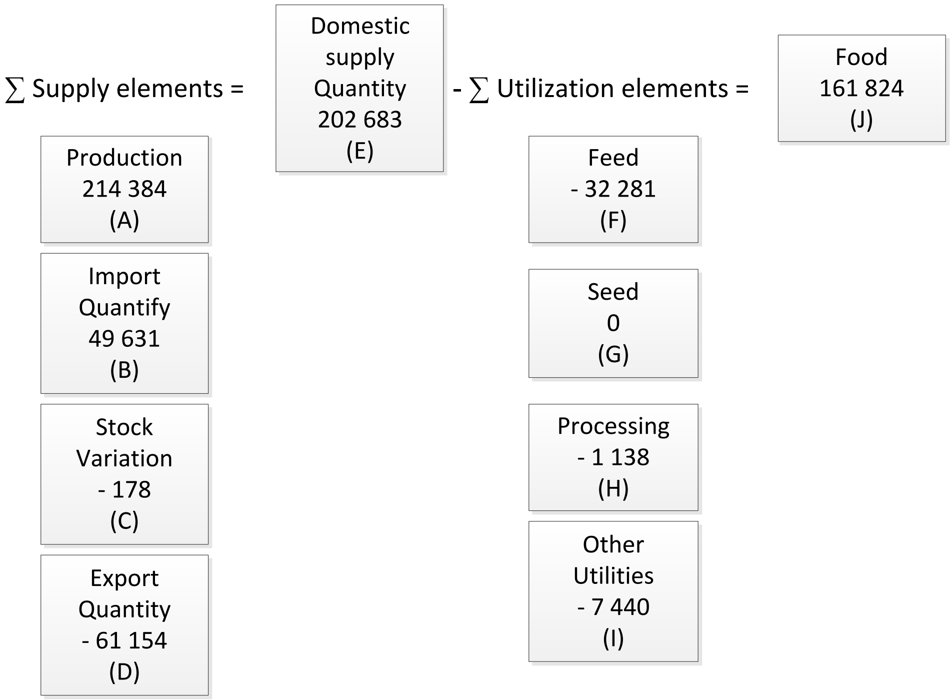

Figure 9 Model of the mass flows of milk in Europe, derived from FAO's FBS 2007 presented in 3.3.3. The domestic supply quantity (E) equals the sum of the supply elements production (A), import quantity (B), stock variations (C) and export quantity (D). Food (available for human consumption) (J) is left after withdrawing the utilization elements feed (F), seed (G), processing (H) and other utilities (I) from the domestic supply quantity (E). In total, food available for human consumption was considered as H+J.

Table 21 presents the loss/waste percentages used for calculating losses and waste of milk in Europe, references can be found in Annex 1 Waste percentages of food losses and waste. Table 22 presents the calculations made for quantifying losses and waste in each step of the supply chain.

Table 21 Waste percentages used for milk in Europe, references can be found in Annex 1 Waste percentages of food losses and waste.

Agricultural production	Postharvest handling and storage	Processing and packaging	Distribution	Consumption
3,5%	0.5%	1.2%	0.5%	7%

Table 22 Calculations of losses and waste (1000 tonnes) for milk in Europe, taking into account the loss/waste percentages in Table 21

Step	Calculations
Agricultural production	Losses/waste was calculated as having occurred *before* the production volume (A) was derived. $\frac{0{,}035}{1-0{,}035} \times 214\,384\ (A)\ = 7\,776$
Postharvest handing & storage	$0{,}005\ \times 214\,384(A) = 1\,072$
Processing & packaging	$0{,}012 \times (1\,138(H) + 161\,824(J)) = 1\,988$
Distribution	$0{,}005\ \times (1\,138(H) + 161\,824(J) - 1\,988) = 805$
Consumption	$0.07\ \times (1\,138(H) + 161\,824(J) - 1\,988 - 805) = 11\ \ 212$

Figure 10 shows how the mass flows of eggs were considered.

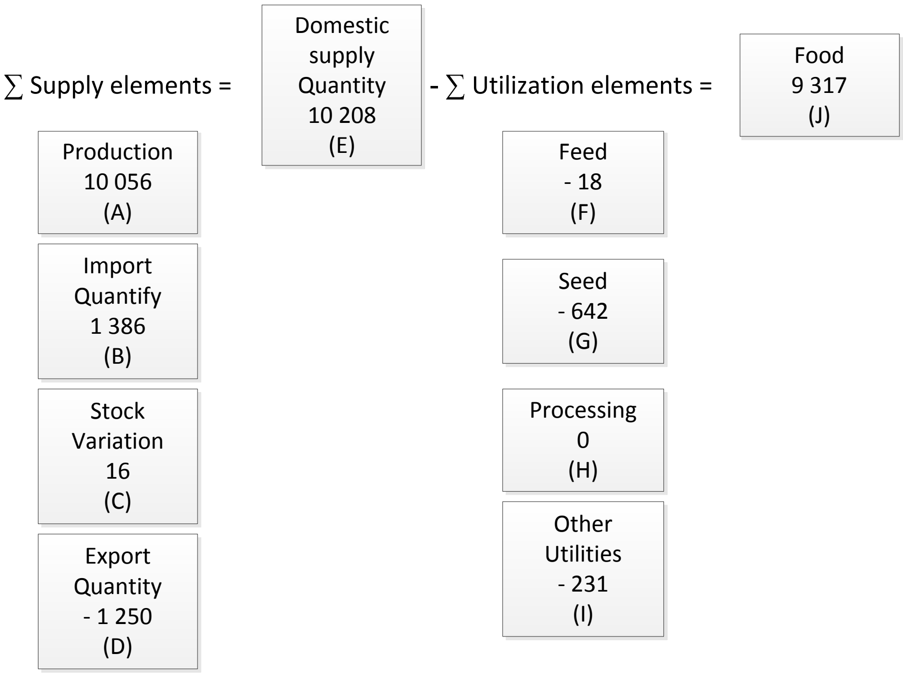

Figure 10 Model of the mass flows of eggs in Europe, derived from FAO's FBS 2007 presented in 3.3.3. The domestic supply quantity (E) equals the sum of the supply elements production (A), import quantity (B), stock variations (C) and export quantity (D). Food (available for human consumption) (J) is left after withdrawing the utilization elements feed (F), seed (G), processing (H) and other utilities (I) from the domestic supply quantity (E). In total, food available for human consumption was considered as H+J.

Table 23 presents the loss/waste percentages used for calculating losses and waste of eggs in Europe, references can be found in Annex 1 Waste percentages of food losses and waste. Table 24 presents the calculations made for quantifying losses and waste in each step of the supply chain.

Table 23 Waste percentages used for eggs in Europe, references can be found in Annex 1 Waste percentages of food losses and waste.

Agricultural production	Postharvest handling and storage	Processing and packaging	Distribution	Consumption
4 %	n/a	0.5%	2%	8%

Table 24 Calculations of losses and waste (1000 tonnes) for eggs in Europe, taking into account the loss/waste percentages in Table 23

Step	**Calculations**
Agricultural production	Losses/waste was calculated as having occurred *before* the production volume (A) was derived. $\frac{0,04}{1-0,04} \times 10\,056(A) = 419$
Postharvest handing & storage	n/a
Processing & packaging	$0,005 \times 9\,317(J) = 47$
Distribution	$0,02 \times (9\,317(J) - 47) = 185$
Consumption	$0.08 \times (9\,317(J) - 47 - 185) = 727$

3.4.8 Summary

Based on the calculation method for each commodity group, described in 3.4, the following volumes of losses and waste were calculated for each region respectively (Table 25-Table 31).

Table 25 Summary of losses and waste (1000 000 tonnes) in Europe

	Agricultural Production	Postharvest handling & storage	Processing & packaging	Distribution	Consumption
Cereals	2,8	4,9	10,8	1,8	22,6
Roots & Tubers	26,9	9,2	7,0	2,1	6,7
Oilseeds & Pulses	1,7	0,2	0,7	0,2	0,6
Fruit & Veg	32,0	6,3	1,8	6,6	21,2
Meat	1,8	0,4	2,8	2,1	5,7
Fish & Seafood	0,6	0,0	0,4	0,4	0,7
Milk & egg	8,2	1,1	2,0	1,0	11,9
Total	74	22	26	14	69

Table 26 Summary of losses and waste (1000 000 tonnes) in North America and Oceania

	Agricultural Production	Postharvest handling & storage	Processing & packaging	Distribution	Consumption
Cereals	4,9	5,7	4,1	0,7	9,2
Roots & Tubers	5,7	2,3	2,2	0,7	2,6
Oilseeds & Pulses	3,3	0,1	0,5	0,1	0,5
Fruit & Veg	14,5	2,4	0,9	4,2	11,1
Meat	2,0	0,5	2,2	1,7	4,4
Fish & Seafood	0,4	0,0	0,3	0,2	0,4
Milk & egg	4,5	0,6	1,1	0,5	14,1
Total	35	12	11	8	42

Table 27 Summary of losses and waste (1000 000 tonnes) in Industrialized Asia

	Agricultural Production	Postharvest handling & storage	Processing & packaging	Distribution	Consumption
Cereals	5,0	25,1	22,3	3,8	37,4
Roots & Tubers	31,1	9,1	3,2	5,5	7,2
Oilseeds & Pulses	1,1	0,4	0,8	0,3	1,1
Fruit & Veg	49,6	34,7	0,4	30,8	54,0
Meat	2,4	0,5	4,0	4,6	5,7
Fish & Seafood	2,9	0,5	1,3	1,1	1,4
Milk & egg	3,7	0,5	0,7	1,3	3,7
Total	96	71	33	47	110

Table 28 Summary of losses and waste (1000 000 tonnes) in Sub-Saharan Africa

	Agricultural Production	**Postharvest handling & storage**	**Processing & packaging**	**Distribution**	**Consumption**
Cereals	4,6	6,1	6,2	0,8	0,8
Roots & Tubers	26,4	29,3	7,4	3,3	1,3
Oilseeds & Pulses	2,8	1,7	0,6	0,4	0,2
Fruit & Veg	7,1	6,0	1,3	9,1	2,2
Meat	2,0	0,1	0,5	0,7	0,2
Fish & Seafood	0,1	0,2	0,1	0,4	0,0
Milk & egg	1,3	2,0	0,0	1,9	0,0
Total	44	45	16	17	5

Table 29 Summary of losses and waste (1000 000 tonnes) in North Africa, Central & Western Asia

	Agricultural Production	**Postharvest handling & storage**	**Processing & packaging**	**Distribution**	**Consumption**
Cereals	4,1	5,5	6,8	2,6	7,6
Roots & Tubers	1,2	1,8	0,3	0,5	0,7
Oilseeds & Pulses	0,8	0,3	0,5	0,2	0,2
Fruit & Veg	20,1	10,0	7,6	6,8	4,3
Meat	0,8	0,0	0,7	0,6	0,9
Fish & Seafood	0,1	0,1	0,1	0,1	0,0
Milk & egg	2,2	3,2	1,0	4,0	1,0
Total	29	21	17	15	15

Table 30 Summary of losses and waste (1000 000 tonnes) in South and Southeast Asia

	Agricultural Production	**Postharvest handling & storage**	**Processing & packaging**	**Distribution**	**Consumption**
Cereals	25,1	34,6	17,6	3,0	9,0
Roots & Tubers	6,3	19,0	0,5	5,4	1,4
Oilseeds & Pulses	6,8	10,6	1,5	1,1	0,5
Fruit & Veg	37,7	19,2	2,4	19,3	11,8
Meat	1,4	0,1	1,2	1,5	0,8
Fish & Seafood	0,9	1,0	0,5	1,6	0,2
Milk & egg	6,2	9,1	2,5	12,5	1,2
Total	85	94	26	45	25

Table 31 Summary of losses and waste (1000 000 tonnes) in Latin America

	Agricultural Production	**Postharvest handling & storage**	**Processing & packaging**	**Distribution**	**Consumption**
Cereals	5,4	3,4	5,2	2,2	5,2
Roots & Tubers	7,8	6,8	2,4	0,7	0,5
Oilseeds & Pulses	1,4	0,6	0,6	0,3	0,3
Fruit & Veg	29,1	12,0	7,3	4,8	3,4
Meat	2,6	0,5	1,8	1,7	1,9
Fish & Seafood	0,5	0,4	0,1	0,2	0,1
Milk & egg	3,0	4,3	1,3	5,2	2,5
Total	50	28	19	15	14

4 Discussion

This report describes the methodology used for the report "*Global food losses and food waste – extent, causes and prevention*" (FAO 2011) based on two studies carried out by SIK.

FAO's FBS enables to quantify food losses/waste globally using the same data source for food supplies. The FBS also enables quantifying losses/waste roughly in different steps of the supply chain. Due to lack of sufficient data, the results in "*Global food losses and food waste – extent, causes and prevention*" must however be taken with great caution; data on weight percentages of losses and waste, especially for low income countries and certain steps of the supply chain were to a high extent lacking.

Input data regarding waste percentages of losses and waste in different steps of the food supply chain were insufficient to fulfill the scope of the study and in many cases uncertain. In general, food loss levels in primary production (both farm agriculture and fishery) are for many commodities unknown or difficult to determine, e.g. because harvest losses sometimes are ploughed back in the soils (Stuart, 2009). Losses and waste in the processing and retail stages are generally also difficult to estimate since there are few public data available. Input data regarding waste percentages were especially lacking for the low income countries.

The applied grouping of several countries into one region made it difficult to produce results relevant for each country within that region. For example, the region Na,WA&CA (including countries in North Africa, Western Asia & Central Asia) includes countries quite different from each other considering e.g. GDP per capita, population sizes and urbanization levels, which most likely have influence on the levels of losses/waste occurring. In other words, loss/waste percentages for a region as a whole may not be representative for all countries included in that region.

Due to lack of data, assumptions on food loss/waste levels had to be made which were based on the assumption that food loss/waste levels increases with increasing regional average food consumption level, GDP per capita and urbanization level. If these factors do influence food loss/waste and if so, how, is uncertain and the assumptions must therefore also be viewed as very uncertain.

One of the major results from the study "*Global food losses and food waste – extent, causes and prevention*" is that there are major gaps in the knowledge of how much food that is lost and wasted globally each year. Food security is a major problem in rural and poor regions of the developing world. Despite this, little documentation is available on how much food that is actually lost and wasted globally. Further research is therefore suggested and encouraged. Preferably, this research should be based on case studies of both the amounts of losses and waste and the root causes of losses and waste throughout the supply chain as well as in different parts of the world. Drawn from the root causes the most efficient ways of prevention can be identified.

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Annex 1 Waste percentages of food losses and waste

The FAO publication *Global food losses and food waste* (FAO 2011) presents the loss/waste data *as percentage of the initial (potential) production* (figures 3-9 in the FAO publication). The initial (potential) production refers to the *hypothetical* reference volume required to produce a given amount of consumed food, based on Table 33-Table 39. If the percentages below (Table 33-Table 39) are represented by the letters a, s, p, d and c respectively for the five steps in the supply chains (whereby 100% =1 and 5% = 0.05 etc.), the fraction of initial (potential) production lost/wasted in each step of the supply chain is calculated as described in Table 32.

Table 32 does not describe *how the volumes* of losses/waste in each step of the supply chain were quantified; the quantification of volumes is based on different supply and utilization elements of the Food Balance Sheets, as described in section 3.4.

Table 32 Equations for deriving figures 3-9 in in the FAO publication Global Food Losses and Food Waste, based on Table 33-Table 39

	Agricultural Production	Postharvest handling & storage	Processing & packaging	Distribution	Consumption
Cereals	a	s(1-a)	p(1-a)(1-s)	d(1-a)(1-s)(1-p)	c(1-a)(1-s)(1-p)(1-d)

Table 33, Table 34 and Table 35 present the estimated and assumed waste percentages used when quantifying losses and waste for the commodity groups and for the different steps of the food supply chain in Europe, North America & Oceania and Industrialized Asia respectively. All references are indexed in the tables and described below, together with information on where we have made assumptions due to data gaps.

Table 33 Estimated/assumed waste percentages for each commodity group in each step of the FSC for Europe;m=milling, f=fresh, p=processed

	Agricultural Production	Postharvest handling & storage	Processing & packaging	Distribution	Consumption
Cereals	2% [1]	4% [2]	0.5%(m), 10%(p) [3]	2% [4]	25% [5]
Roots & Tubers	20% [6]	9% [7]	15% [8]	7%(f), 3%(p) [9]	17%(f), 12%(p) [10]
Oilseeds & Pulses	10% [11]	1% [12]	5% [13]	1% [14]	4% [15]
Fruit & Veg	20% [16]	5% [17]	2% [18]	10%(f), 2%(p) [19]	19%(f), 15%(p) [20]
Meat	3.2% [21]	0.7% [22]	5% [23]	4% [24]	11% [25]
Fish & Seafood	9.4% [26]	0.5% [27]	6% [28]	9%(f), 5%(p) [29]	11%(f), 10(p) [30]
Milk	3.5% [31]	0.5% [32]	1.2% [33]	0.5% [34]	7% [35]
Eggs	4% [36]	- [37]	0.5% [38]	2% [39]	8% [40]

Europe:

1. (Smil 2004): Harvest losses of Canadian barley: ranging between 0.07 and 2.81% when harvest is done in optimal time.
   We assume similar harvest losses for European cereals
2. (FAOSTAT 2010): Losses during transport, handling and storage of cereals between farm and distribution.
3. (Cederberg 2008): Losses during wheat milling in a very well-run Swedish mill: 4/28 232 (tons) = 0,014%.
   (Schneider and Scherhaufer 2009): Losses during industrial bread baking in Austria, approximately 10%.
   (Söderlund 2007): Over production during industrial bread baking in Sweden, approximately 13%.
4. (Kantor 1997): Edible losses in American retail stores, grains 2%

We assume similar losses in Europe.

5. (WRAP 2008): Proportion of avoidable food waste in UK households, staple foods 16% and standard bread 29%.
   We assume an average avoidable food loss of 25% for the whole group of cereals at the consumer level in Europe.
6. (Mattsson 2001): Potatoes sorted out at Swedish potato farms due to quality standards, average 20%.
7. (FAOSTAT 2010): Losses during transport, handling and storage of roots and tubers between farm and distribution.
8. (Somsen 2004): Average losses during European french frites production 15%. Taken into account are losses due to: sorting, size reduction, transportation in processing and disturbances during production.
9. (Buzby, Farah Wells et al. 2009): Estimated loss of fresh potato in American supermarkets 7%
   We assume similar losses in Europe. Estimated loss of processed potato in European supermarkets, assumed.
10. (WRAP 2008): Proportion of avoidable food waste in UK households, fresh potato 17% and processed potato 12%.
11. (Hobson and Bruce 2002): Harvest losses of oilseed rape in the UK: ideal conditions 2-5%, loss of 20-25% has been recorded and losses can be as high as 50%.
12. (FAOSTAT 2010): Losses during transport, handling and storage of oil crops between farm and distribution.
13. Assumption
14. (Kantor 1997): Edible losses in American retail stores, fats and oils 1%
    We assume similar losses in Europe
15. (WRAP 2008): Proportion of avoidable food waste in UK households, oils and fats 4%
16. (Davis, Wallman et al. 2011): Carrots grown at Swedish farms without storage: Wasted=21 ton/ha, Net yield=61ton/ha, Waste=21/(21+61)=25%, Onions 16%, Tomatoes assumed 10-15%.
    (Stuart 2009): “Between 25-40% of most British-grown fruit & vegetable crops are rejected by supermarkets”.
17. (FAOSTAT 2010): Losses during transport, handling and storage of fruit and vegetables between farm and distribution.
18. (AWARENET 2003): European fruit and vegetable juice production: solid matter and processing scraps 2%.
19. (Gustavsson and Stage 2011): Average registered waste of fruit and vegetables in Swedish retail stores 4%.
    (Åhnberg and Strid 2010): Approximately 5% of fruit and vegetables entering Swedish retail stores are due to poor quality sent back to the supplier (and assumed wasted).
    Estimated loss of processed fruit and vegetables in European retail stores, assumed.
20. (WRAP 2008): Proportion of avoidable food waste in UK households, “fresh fruit” 18%, “fresh vegetables and salads” 20%, “processed vegetables and salads” 14% and “processed fruit” 16%
21. *Mortality during breeding:*
    (McConnel, Lombard et al. 2008): Death loss at USA farms: 4.8% for dairy cows and 1-1.5% for beef cows and feed lot animals.
    (Cornell_Waste_Management_Institute 2002): Typical death loss at U.S. farms: 2% for dairy herds and 0.5% in beef herds.
    We assume an average 2.3%mortality rate for cattle bred in Europe.
    (Svenska_Pig 2010): Mortality rate at Swedish farms, 2.5% for fatty pigs
    We assume an average 2.5% mortality rate for pigs bred in Europe.
    (Cederberg 2009): Mortality rate at Swedish farms, 3.5-4.5% for broilers
    We assume an average 4% mortality rate for chickens bred in Europe.
    (Grimes Undated): Average total mortality of turkeys on pasture from hatch to market is expected to be 15-25%, with good care 10%.
    (HSUS Undated): The U.S. turkey industry tolerates mortality rates of 7-10%.
    (Wallman 2009): Mortality rate at Swedish farms: 8% for turkeys.
    We assume an average 10% mortality rate for turkeys bred in Europe.
    (Wallman 2011): Mortality rate at Swedish farms, 3-4% for sheep and 4-19% for lamb, including stillborn animals
    We assume an average 10% mortality rate for sheep bred in Europe.
    A weighted average for European agricultural production of cattle, pig, chicken, turkey and sheep: 3.2%
22. *Mortality during transport to slaughter:*
    (Malena, Voslářová et al. 2007): Mortality rate during transport to slaughter in Czech Republic: excluded dairy cows 0.0396%, fattened cattle 0.0069% and fattened pigs 0.1075%
    We assume an average 0.013% mortality rate for cattle transported to slaughter in Europe.

We assume an average 0.11% mortality rate for pigs transported to slaughter in Europe.
(Petracci, Bianchi et al. 2006): Mortality rate during transport to slaughter in Italy: broilers 0.35%, turkeys 0.38% and spent hens 1.22%
(Ritz 2005): National mortality rate during transport to slaughter in the U.S: birds 0.35-0.37%
We assume an average 0.35% mortality rate for chickens transported to slaughter in Europe.
We assume an average 0.38% mortality rate for turkeys transported to slaughter in Europe.
(Knowles 1998): Mortality rate during transport to slaughter in Europe, sheep 0.018%
We assume an average 0.018% mortality rate for sheep transported to slaughter in Europe.
Rejection at slaughterhouse:
(Alton, Pearl et al. 2010): Of 1 162 410 processed cattle in Ontario abattoirs, 6 875 carcasses were condemned (approximately 0.6%).
We assume 0.6% of cattle and sheep are rejected at slaughter in Europe.
(Belk 2002): Of U.S. market hogs sent to slaughter, 0.2% were condemned (with 36% of the 0.2% due to dead-on-arrivals or dead-in-pens).
We assume 0.12% of pigs are rejected at slaughter in Europe.
(Haslam 2008): Mean percentage of rejected broiler chicken carcass was 1.23%.
We assume 1.3% of chickens are rejected at slaughter in Europe.
(Lupo, Le Bouquin et al. 2010): Within-flock weighted average condemnation proportion of turkey broilers in France 1.8%.
We assume 1.5% of turkeys are rejected at slaughter in Europe.
A weighted average for European mortality during transport to slaughter and rejection at slaughterhouse for cattle, pig, chicken, turkey and sheep: 0.7%

23. (AWARENET 2003): European beef slaughtering: "trimming scraps" 0.7-3%, European pig slaughtering: "Others" 3-6%
24. (Buzby, Farah Wells et al. 2009): Average 2005-2006 losses in U.S supermarkets, pork, beef, chicken and turkey 4%
    We assume similar losses in Europe
25. (WRAP 2008): Proportion of avoidable food waste in UK households, meat and fish 11%
26. Estimated discard rate based on type of fishing gear used in the region. For information on how the estimations were made, see Annex 3 Discards as potential human consumption.
27. Assumption made from (Nor 2004): The preparation of fish in developed countries is good, gutting and filleting is often done at sea along with chilling and freezing. By-products are taken care of and used for other processes. Refrigerated transportation and marketing system facilities are often also well established.
28. (AWARENET 2003): European fish canning: rejected fish 3% and scraps 5%
29. (Buzby, Farah Wells et al. 2009): Average 2005-2006 losses in U.S. supermarkets, fresh fish and shellfish 9 %; processed fish and shellfish, assumed
    We assume similar losses in Europe
30. (WRAP 2008): Proportion of avoidable food waste in UK households, (fresh) meat and fish 11%
    (USDA 2010): Cooking loss and uneaten food at consumer level, canned tuna/salmon/sardines/shellfish 10%
31. (Hospido and Sonesson 2005): Assumed average milk losses caused by mastitis infection in dairy cows.
    Mastitis (udder inflammation) affect up to 20-50% of dairy cows per lactation in European countries, precise data on incidence rate is not possible to give. Due to mastitis, milk is lost in the farm production due to decreased milk yield of the cow and due to discarded milk. Based on (Hospido and Sonesson 2005), we estimated the average milk production loss at 600 kg milk/dairy cow and case, and discarded milk at 200 kg milk/dairy cow and case. We assumed average incident rate to be 30%. Milk lost due to mastitis is thus estimated at 800 kg * 0.3 = 240 kg/dairy cow and lactation (year). A normal milk yield in developed countries is 7500 kg/cow*yr (240/7500 = 3.2%). We used an average loss percentage of 3.5 % for milk in agricultural production which is based on the fact that mastitis is the most severe illness. We suggest that it is reasonable that these losses are in the range 2 – 5 % of milk production at the farm.
32. Assumption
33. (Berlin, Sonesson et al. 2008), (Berlin 2010): Weighted average for losses during processing of milk (2%), cheese (0%) and yoghurt (6%) in Swedish dairies.
    Weighted average losses in European milk processing 1.2%
34. (Berlin, Sonesson et al. 2008; Berlin 2010): Weighted average for losses during distribution of milk (0.6%), cheese (0%) and yoghurt (0.3%).
    Estimated average losses in European dairy distribution 0.5%
35. (WRAP 2008): Proportion of avoidable food waste in UK households, milk 7%
36. (Aerni 2005): Losses of egg in agricultural production due to mortality of layer hens and cannibalism were estimated at an average of 3.9% over a year´s egg production and broken eggs etc. in handling

at farms were assumed to be 0.1%. Total losses in agricultural production were set at 4 % of production.

37. See 38
38. (Sonesson 2008):
    We assume a total of 0.5% losses in both postharvest handling and processing.
39. (Kantor 1997): Edible losses in American retail stores, eggs 2%
    We assume similar losses in Europe
40. (WRAP 2008): Proportion of avoidable food waste in UK households, dairy and eggs 8%

Table 34 Estimated/assumed waste percentages for each commodity group in each step of the FSC for North America & Oceania; m=milling, f=fresh, p=processed

	Agricultural Production	Postharvest handling & storage	Processing & packaging	Distribution	Consumption
Cereals	2% [1]	2% [2]	0.5%(m), 10%(p) [3]	2% [4]	27% [5]
Roots & Tubers	20% [6]	10% [7]	15% [8]	7%(f), 3%(p) [9]	30%(f), 12%(p) [10]
Oilseeds & Pulses	12% [11]	0% [12]	5% [13]	1% [14]	4% [15]
Fruit & Veg	20% [16]	4% [17]	2% [18]	12%(f), 2%(p) [19]	28%(f), 10%(p) [20]
Meat	3.7% [21]	1.0% [22]	5% [23]	4% [24]	11% [25]
Fish & Seafood	12% [26]	0.5% [27]	6% [28]	9%(f), 5%(p) [29]	33%(f), 10%(p) [30]
Milk	3.5% [31]	0.5% [32]	1.2% [33]	0.5% [34]	15% [35]
Eggs	4% [36]	- [37]	0.5% [38]	2% [39]	15% [40]

North America & Oceania (NA&Oce):

1. (Smil 2004): Harvest losses of Canadian barley: ranging between 0.07 and 2.81% when harvest is done in optimal time.
2. (FAOSTAT 2010): Losses during transport, handling and storage of cereals between farm and distribution.
3. (Cederberg 2008): Losses during wheat milling in a well-run Swedish mill: 4/28 232 (tons) = 0,014%.
   (Schneider and Scherhaufer 2009): Losses during industrial bread baking in Austria, approximately 10%.
   (Söderlund 2007): Over production during industrial bread baking in Sweden, approximately 13%.
   We assume similar losses in NA&Oce
4. (Kantor 1997): Edible losses in American retail stores, grains 2%.
5. (WRAP 2008): Proportion of avoidable food waste in UK households, standard bread 29%.
   We assume similar losses in NA&Oce
   (USDA 2010): Cooking loss and uneaten food at consumer level, 20% for staple food.
6. (Mattsson 2001): Potatoes sorted out at Swedish potato farms due to quality standards, average 20%.
   We assume similar losses in NA&Oce
7. (FAOSTAT 2010): Losses during transport, handling and storage of roots and tubers between farm and distribution.
8. (Somsen 2004): Average losses during European french frites production 15%. Taken into account are losses due to: sorting, size reduction, transportation in processing and disturbances during production.
   We assume similar losses in NA&Oce
9. (Buzby, Farah Wells et al. 2009): Estimated loss in American supermarkets, fresh potato 7%.
   Estimated loss for processed potato, assumed.
10. (USDA 2010): Cooking loss and uneaten food at consumer level, fresh potatoes 30%
    (WRAP 2008) Proportion of avoidable food waste in UK households, processed potato 12%.
    We assume similar losses in NA&Oce
11. (Kulkarni Undated): Field losses of soybeans in the U.S: commonly around 10%, sometimes 15-20% due to careless harvest operations.
12. (FAOSTAT 2010): Losses during transport, handling and storage of oil crops between farm and distribution.
13. Assumption
14. (Kantor 1997): Edible losses in American retail stores, fats and oils 1%
15. (WRAP 2008): Proportion of avoidable food waste in UK households, oils and fats 4%
    We assume similar losses in NA&Oce
16. (Davis, Wallman et al. 2011): Carrots grown at Swedish farms without storage: Wasted=21 ton/ha, Net yield=61ton/ha, Waste=21/(21+61)=25%, Onions 16%, Tomatoes assumed 10-15%.
    (Stuart 2009): "Between 25-40% of most British-grown fruit & vegetable crops are rejected by supermarkets" Stuart (2009).
    We assume similar losses in NA&Oce
17. (FAOSTAT 2010): Losses during transport, handling and storage of fruit and vegetables between farm and distribution.
18. (AWARENET 2003): European fruit and vegetable juice production: solid matter and processing scraps 2%.
    We assume similar losses in NA&Oce

19. (Buzby, Farah Wells et al. 2009): Estimated loss of fresh fruit and vegetables in American supermarkets 9%
    (Åhnberg and Strid 2010): Approximately 5% of fruit and vegetables entering Swedish retail stores are due to poor quality sent back to the supplier (assumed wasted).
    We assume similar losses in NA&Oce
20. (USDA 2010): Cooking loss and uneaten food at consumer level ,fresh fruit and vegetables 20-35%
21. *Mortality during breeding:*
    (McConnel, Lombard et al. 2008): Death loss at USA farms: 4.8% for dairy cows and 1-1.5% for beef cows and feed lot animals.
    (Cornell_Waste_Management_Institute 2002): Typical death loss at U.S. farms: 2% for dairy herds and 0.5% in beef herds.
    We assume an average 2.3%mortality rate for cattle bred in the NA&Oce.
    (Svenska_Pig 2010): Mortality at Swedish farms, 2.5% for fatty pigs
    We assume an average 2.5% mortality rate for pigs bred in NA&Oce.
    (Cederberg 2009): Mortality at Swedish farms, 3.5-4.5 % for broilers.
    We assume an average 4% mortality rate for chickens bred in NA&Oce.
    (Grimes Undated): Average total mortality of turkeys on pasture from hatch to market is expected to be 15-25%, with good care 10%.
    (HSUS Undated): The U.S. industry turkey industry tolerates mortality rates of 7-10%.
    (Wallman 2009): Mortality rate at Swedish farms: 8% for turkeys.
    We assume an average 10% mortality rate for turkeys bred in NA&Oce.
    (Wallman 2011): Mortality rate at Swedish farms, 3-4 % for sheep and 4-19% for lamb, including still born animals.
    We assume an average 10% mortality rate for sheep bred in NA&Oce.
    A weighted average for NA&Oce agricultural production of cattle, pig, chicken, turkey and sheep: 3.7%
22. *Mortality during transport to slaughter:*
    (Malena, Voslářová et al. 2007): Mortality rate during transport to slaughter in Czech Republic: excluded dairy cows 0.0396%, fattened cattle 0.0069% and fattened pigs 0.1075%
    We assume an average 0.013% mortality rate for cattle transported to slaughter in NA&Oce.
    We assume an average 0.11% mortality rate for pigs transported to slaughter in NA&Oce.
    (Petracci, Bianchi et al. 2006): Mortality rate during transport to slaughter in Italy: broilers 0.35%, turkeys 0.38% and spent hens 1.22%
    (Ritz 2005): National mortality rate during transport to slaughter in the U.S: birds 0.35-0.37%
    We assume an average 0.35% mortality rate for chickens transported to slaughter in NA&Oce.
    We assume an average 0.38% mortality rate for turkeys transported to slaughter in NA&Oce.
    (Knowles 1998): Mortality rate during transport to slaughter in Australia, sheep 0.74-1.63%
    We assume an average 1% mortality rate for sheep transported to slaughter in NA&Oce.
    Rejection at slaughterhouse:
    (Alton, Pearl et al. 2010): Of 1 162 410 processed cattle in Ontario abattoirs, 6 875 carcasses were condemned (approximately 0.6%).
    We assume 0.6% of cattle and sheep are rejected at slaughter in NA&Oce.
    (Belk 2002): Of U.S. market hogs sent to slaughter 0.2% were condemned (with 36% of the 0.2% due to dead-on-arrivals or dead-in-pens).
    We assume 0.12% of pigs are rejected at slaughter in NA&Oce.
    (Haslam 2008): Mean percentage of rejected broiler chicken carcass was 1.23%.
    We assume 1.3% of chickens are rejected at slaughter in NA&Oce.
    (Lupo, Le Bouquin et al. 2010): Within-flock weighted average condemnation proportion of turkey broilers in France 1.8%.
    We assume 1.5% of turkeys are rejected at slaughter in NA&Oce.
    A weighted average for NA&Oce mortality during transport to slaughter and rejection at slaughterhouse for cattle, pig, chicken, turkey and sheep: 1.0%
23. (AWARENET 2003): European beef slaughtering: "trimming scraps" 0.7-3%, European pig slaughtering: "Others" 3-6%
    We assume similar losses in NA&Oce
24. (Buzby, Farah Wells et al. 2009): Average 2005-2006 losses in U.S. supermarkets, pork, beef, chicken and turkey 4%
25. (WRAP 2008): Proportion of avoidable food waste in UK households, meat and fish 11%
    We assume similar losses in NA&Oce
26. Estimated discard rate based on type of fishing gear used in the region. For information on how the estimations were made, see Annex 3 Discards as potential human consumption.
27. Assumption made from (Nor 2004): The preparation of fish in developed countries is good, gutting and filleting is often done at sea along with chilling and freezing. By-products are taken care of and

used for other processes. Refrigerated transportation and marketing system facilities are often also well established.

28. (AWARENET 2003): European fish canning: rejected fish 3% and scraps 5%
    We assume similar losses in NA&Oce
29. (Buzby, Farah Wells et al. 2009): Average 2005-2006 losses in U.S. supermarkets, (fresh) fish and shellfish 9 %; processed fish and seafood, assumed
30. (USDA 2010): Cooking losses and uneaten food at consumer level, fresh and frozen fish and shellfish 33%
    (USDA 2010): Cooking loss and uneaten food at consumer level, canned tuna/salmon/sardines/shellfish 10%
31. (Hospido and Sonesson 2005): Assumed average milk losses caused by mastitis infection in dairy cows.
    Mastitis (udder inflammation) affect up to 20-50% of dairy cows per lactation in European countries, precise data on incidence rate is not possible to give. Due to mastitis, milk is lost in the farm production due to decreased milk yield of the cow and due to discarded milk. Based on (Hospido and Sonesson 2005), we estimated the average milk production loss at 600 kg milk/dairy cow and case, and discarded milk at 200 kg milk/dairy cow and case. We assumed average incident rate to be 30%. Milk lost due to mastitis is thus estimated at 800 kg * 0.3 = 240 kg/dairy cow and lactation (year). A normal milk yield in developed countries is 7500 kg/cow*yr (240/7500 = 3.2%). We used an average loss percentage of 3.5 % for milk in agricultural production which is based on the fact that mastitis is the most severe illness. We suggest that it is reasonable that these losses are in the range 2 – 5 % of milk production at the farm.
    The same was assumed for NA&Oce.
32. Assumption
33. (Berlin, Sonesson et al. 2008), (Berlin 2010): Weighted average for losses during processing of milk (2%), cheese (0%) and yoghurt (6%) in Swedish dairies.
    Weighted average losses in Swedish milk processing 1.2%
    We assume similar losses in NA&Oce
34. (Berlin, Sonesson et al. 2008), (Berlin 2010): Weighted average for losses during distribution of milk (0.6%), cheese (0%) and yoghurt (0.3%).
    Estimated average losses in Swedish milk distribution 0.5%
    We assume similar losses in NA&Oce
35. (USDA 2010): Cooking loss and uneaten food at consumer level, dry milk 1%, milk 20% and cheddar cheese 13%. We assume an average of 15%.
36. (Aerni 2005): Losses of egg in agricultural production due to mortality of layer hens and cannibalism were estimated at an average of 3.9% over a year´s egg production and broken eggs etc. in handling at farms were assumed to be 0.1%. Total losses in agricultural production were set at 4% of production.
37. See 38
38. (Sonesson 2008): Losses during egg packaging in Sweden was estimated at 0.3%. Most eggs are not further processed but continue straight to distribution.
39. (Kantor 1997): Edible losses in American retail stores, eggs 2%
40. (USDA 2010): Cooking loss and uneaten food at consumer level, eggs 15%

Table 35 Estimated/assumed waste percentages for each commodity group in each step of the FSC for Industrialized Asia; m=milling, f=fresh, p=processed

	Agricultural Production	**Postharvest handling & storage**	**Processing & packaging**	**Distribution**	**Consumption**
Cereals	2% [1]	10% [2]	0,5%(m), 10%(p) [3]	2% [4]	20% [5]
Roots & Tubers	20% [6]	7% [7]	15% [8]	9%(f), 3%(p) [9]	10%(f), 12%(p) [10]
Oilseeds & Pulses	6% [11]	3% [12]	5% [13]	1% [14]	4% [15]
Fruit & Veg	10% [16]	8% [17]	2% [18]	8%(f), 2%(p) [19]	15%(f), 8%(p) [20]
Meat	3.1% [21]	0.6% [22]	5% [23]	6% [24]	8% [25]
Fish & Seafood	15% [26]	2% [27]	6% [28]	11%(f), 5%(p) [29]	8%(f), 7%(p) [30]
Milk	3.5% [31]	1% [32]	1.2% [33]	0.5% [34]	5% [35]
Eggs	6% [36]	- [37]	0.5% [38]	4% [39]	5% [40]

Industrialized Asia (Ind. Asia):

1. (Smil 2004): Harvest losses of Canadian barley: ranging between 0.07 and 2.81% when harvest is done in optimal time.
   We assume similar losses in Ind. Asia
2. (FAOSTAT 2010): Losses during transport, handling and storage of cereals between farm and distribution.
3. (Cederberg 2008): Losses during wheat milling in a well-run Swedish mill: 4/28 232 (tons) = 0,014%.
   (Schneider and Scherhaufer 2009): Losses during industrial bread baking in Austria, approximately 10%.
   (Söderlund 2007): Over production during industrial bread baking in Sweden, approximately 13%.
   We assume similar losses in Ind. Asia
4. (Kantor 1997): Edible losses in American retail stores, grains 2%
   We assume similar losses in Ind. Asia
5. Assumption
6. (Mattsson 2001): Potatoes sorted out at Swedish potato farms due to quality standards, average 20%.
   We assume similar losses in Ind. Asia
7. (FAOSTAT 2010): Losses during transport, handling and storage of roots and tubers between farm and distribution.
8. (Somsen 2004): Average losses during European french frites production 15%. Taken into account are losses due to: sorting, size reduction, transportation in processing and disturbances during production.
   We assume similar losses in Ind. Asia
9. Assumption
10. Assumption
11. (FAO 2010): harvest losses of soybeans 4-7% using combine harvester.
12. (FAOSTAT 2010): Losses during transport, handling and storage of oil crops between farm and distribution.
13. Assumption
14. Assumption
15. Assumption
16. Assumption: we assume that less fruit and vegetables are sorted out at Asian farms, due to fewer quality standards by Asian retailers and consumers.
17. (FAOSTAT 2010): Losses during transport, handling and storage of fruit and vegetables between farm and distribution.
18. (AWARENET 2003): European fruit and vegetable juice production: solid matter and processing scraps 2%.
    We assume similar losses in Ind. Asia
19. Assumption
20. Assumption
21. *Mortality during breeding:*
    (McConnel, Lombard et al. 2008): Death loss at USA farms: 4.8% for dairy cows and 1-1.5% for beef cows and feed lot animals.
    (Cornell_Waste_Management_Institute 2002): Typical death loss at U.S. farms: 2% for dairy herds and 0.5% in beef herds.
    We assume an average 2.3% mortality rate of cattle bred in Ind. Asia
    (Svenska_Pig 2010): Mortality at Swedish farms, 2.5% for fatty pigs

We assume an average 2.5% mortality rate of pigs bred in Ind. Asia
(Cederberg 2009): Mortality at Swedish farms, 3.5-4.5 % for broilers
We assume an average 4% mortality rate of chickens and ducks bred in Ind. Asia
(Grimes Undated): Average total mortality of turkeys on pasture from hatch to market is expected to be 15-25%, with good care 10%.
(HSUS Undated): The U.S. industry turkey industry tolerates mortality rates of 7-10%.
(Wallman 2009): Mortality rate at Swedish farms: 8% for turkeys.
We assume an average 10% mortality rate of turkeys bred in Ind. Asia
(Wallman 2011): Mortality rate at Swedish farms, 3-4 % for sheep and 4-19% for lamb, including still born animals.
We assume an average 10% mortality of sheep bred in Ind. Asia
A weighted average for Ind. Asia agricultural production of cattle, pig, chicken, turkey, ducks, sheep and goat: 3.1%

22. *Mortality during transport to slaughter:*
    (Malena, Voslářová et al. 2007): Mortality rate during transport to slaughter in Czech Republic: excluded dairy cows 0.0396%, fattened cattle 0.0069% and fattened pigs 0.1075%
    We assume an average 0.013% mortality rate of cattle transported to slaughter in Ind. Asia
    We assume an average 0.11% mortality rate of pigs transported to slaughter in Ind. Asia
    (Petracci, Bianchi et al. 2006): Mortality rate during transport to slaughter in Italy: broilers 0.35%, turkeys 0.38% and spent hens 1.22%
    (Ritz 2005): National mortality rate during transport to slaughter in the U.S: birds 0.35-0.37%
    We assume an average 0.35% mortality rate of chickens and ducks transported to slaughter in Ind. Asia
    We assume an average 0.38% mortality rate of turkeys transported to slaughter in Ind. Asia
    (Knowles 1998): Mortality rate during transport to slaughter in Australia, sheep 0.74-1.63%
    We assume an average 1% mortality rate of sheep transported to slaughter in Ind. Asia
    Rejection at slaughterhouse:
    (Alton, Pearl et al. 2010): Of 1 162 410 processed cattle in Ontario abattoirs, 6 875 carcasses were condemned (approximately 0.6%).
    We assume 0.6% of cattle, sheep and goat are rejected at slaughterhouse in Ind. Asia.
    (Belk 2002): Of U.S. market hogs sent to slaughter 0.2% were condemned (with 36% of the 0.2% due to dead-on-arrivals or dead-in-pens).
    We assume 0.12% of pigs are rejected at slaughterhouse in Ind. Asia
    (Haslam 2008): Mean percentage of rejected broiler chicken carcass was 1.23%.
    We assume 1.3% of chickens and ducks are rejected at slaughterhouse in Ind. Asia
    (Lupo, Le Bouquin et al. 2010): Within-flock weighted average condemnation proportion of turkey broilers in France 1.8%.
    We assume 1.5% of turkeys are rejected at slaughterhouse in Ind. Asia
    A weighted average for Ind. Asia mortality during transport to slaughter and rejection at slaughterhouse for cattle, pig, chicken, ducks, turkey, sheep and goat: 0.6%
23. (AWARENET 2003): European beef slaughtering: “trimming scraps” 0.7-3%, European pig slaughtering: “Others” 3-6%
    We assume similar losses in Ind. Asia
24. Assumption
25. Assumption
26. Estimated discard rate based on type of fishing gear used in the region. For information on how the estimations were made, see Annex 3 Discards as potential human consumption.
27. Assumption made from (Nor 2004): The preparation of fish in developed countries is good, gutting and filleting is often done at sea along with chilling and freezing. By-products are taken care of and used for other processes. Refrigerated transportation and marketing system facilities are often also well established. Korea does however experience substantial postharvest losses of fish.
28. (AWARENET 2003): European fish canning: rejected fish 3% and scraps 5%
    We assume similar losses in Ind. Asia
29. Assumption
30. Assumption
31. (Hospido and Sonesson 2005): Assumed average milk losses caused by mastitis infection in dairy cows.
    Mastitis (udder inflammation) affect up to 20-50% of dairy cows per lactation in European countries, precise data on incidence rate is not possible to give. Due to mastitis, milk is lost in the farm production due to decreased milk yield of the cow and due to discarded milk. Based on (Hospido and Sonesson 2005), we estimated the average milk production loss at 600 kg milk/dairy cow and case, and discarded milk at 200 kg milk/dairy cow and case. We assumed average incident rate to be 30%. Milk lost due to mastitis is thus estimated at 800 kg * 0.3 = 240 kg/dairy cow and lactation (year). A

normal milk yield in developed countries is 7500 kg/cow*yr (240/7500 = 3.2%). We used an average loss percentage of 3.5 % for milk in agricultural production which is based on the fact that mastitis is the most severe illness. We suggest that it is reasonable that these losses are in the range 2 – 5 % of milk production at the farm.
The same was assumed for Ind. Asia.

32. Assumption
33. (Berlin, Sonesson et al. 2008), (Berlin 2010): Weighted average for losses during processing of milk (2%), cheese (0%) and yoghurt (6%) in Swedish dairies.
    Weighted average losses in Swedish milk processing 1.2%
    We assume similar losses in Ind. Asia
34. (Berlin, Sonesson et al. 2008), (Berlin 2010): Weighted average for losses during distribution of milk (0.6%), cheese (0%) and yoghurt (0.3%).
    Estimated average losses in Swedish dairy distribution 0.5%
    We assume similar losses in Ind. Asia
35. Assumption
36. (Huq 2002): Mortality rate of layer hens in a poultry farm in Bangladesh: 9% for unvaccinated birds and 4.5% for birds vaccinated against IBD and challenged with the IBD virus.
37. See 38
38. (Sonesson 2008): Losses during egg packaging in Sweden was estimated at 0.3%. Most eggs are not further processed but continue straight to distribution.
39. Assumption
40. Assumption

Table 36, Table 37, Table 38 and Table 39 present the estimated and assumed waste percentages used when quantifying losses and waste for the commodity groups and for the different steps of the food supply chain in Sub-Saharan Africa, North Africa, West & Central Asia, South & Southeast Asia and Latin America respectively. All references are indexed in the tables and reported below, together with information on where we have made assumptions due to data gaps.

Table 36 Estimated/assumed waste percentages for each commodity group in each step of the food supply chain of Sub-Saharan Africa; m=milling, f=fresh, p=processed

	Agricultural Production	Postharvest handling & storage	Processing & packaging	Distribution	Consumption
Cereals	6% [1]	8% [2]	3.5%(m), 3,5%(p) [3]	2% [4]	1% [5]
Roots & Tubers	14% [6]	18% [7]	15% [8]	5%(f),2% (p) [9]	2%(f), 1%(p) [10]
Oilseeds & Pulses	12% [11]	8% [12]	8% [13]	2% [14]	1% [15]
Fruit & Veg	10% [16]	9% [17]	25% [18]	17%(f), 10%(p) [19]	5%(f), 1%(p) [20]
Meat	19% [21]	0.7% [22]	5% [23]	7% [24]	2% [25]
Fish & Seafood	5.7% [26]	6% [27]	9% [28]	15%(f), 10%(p) [29]	2%(f), 1%(p) [30]
Milk	6% [31]	11% [32]	0.1% [33]	10% [34]	0.1% [35]
Eggs	8% [36]	- [37]	0.1% [38]	3% [39]	1% [40]

Sub-Saharan Africa (SSA):

1. (Smil 2004): Harvest losses in China, rice 7%.
   (FAO 2009): Harvest losses in Sierra Leone, rice 5%
2. (FAOSTAT 2010): Losses during transport, handling and storage of cereals between farm and distribution.
3. (UNIDO 2004): Typical losses during small-scale cereal milling, sorting grain 5-20%, hulling 5-15, packaging flour 2-10% and rejected flour 0-5%. We assume little waste during cereal milling in SSA, an average of 3.5%.
   Typical losses during small-scale bread baking, batch preparation 2-5%, machine washing 2-5%, accidental product breakage 2-5% and rejected packages 2-5%.
4. Assumption
5. Assumption
6. (FAO 2010): Typical harvest losses in Africa, cassava 14%
7. (FAOSTAT 2010): Losses during transport, handling and storage of roots and tubers between farm and distribution.
8. (FAO 2010): Losses during cassava processing in Africa, traditional methods 22% and improved methods 10%.
   (UNIDO 2004): Typical losses during small-scale root crop processing, washing 0-5%, sorting 5-50%, slicing/dicing 5-10%, packaging 0-10% and rejection 0-5%.
9. Assumption
10. Assumption
11. (FAO 2010): Typical harvest losses in developing countries, coconut 5-10% and groundnut 10-20%
12. (FAOSTAT 2010): Losses during transport, handling and storage of oil crops between farm and distribution.
13. Assumption
14. Assumption
15. Assumption
16. (Kitinoja 2010): Typical harvest losses in India, Okra 2-5%, Tomato 4-5% and Mango 2-4%. We assume harvest losses are similar for fruit and vegetables produced in SSA.
    (Lustig 2004): Up to 25-30% of bananas produced in Costa Rica are dumped due to quality standards. Some are used for further processing but a large proportion is left to rotten in field. A lot of bananas are produced and exported in Africa, e.g. Uganda. Losses were therefore assumed to occur in SSA as well.
17. (FAOSTAT 2010): Losses during transport, handling and storage of fruit and vegetables between farm and distribution.
18. (UNIDO 2004): Typical losses during small-scale fruit and vegetable processing, washing 0-10%, sorting 5-50%, slicing/dicing 5-10%, accidental spillage 5-10% and rejected packages 2-5%.

19. (Kitinoja 2010): Average physical losses (sorted out and not sold) for nine fruit and vegetable crops in Ghana, wholesale market 12.9% and retail market 17.4%. Average physical losses (sorted out and not sold) for four fruit and vegetable crops in Rwanda, wholesale market 16.2% and retail market 21.4%. Average physical losses (sorted out and not sold) for seven fruit and vegetable crops in Benin, wholesale market 17.9% and retail market 16.6%.
20. Assumption
21. *Mortality during breeding:*
    (Wymann, Bonfoh et al. 2006): Calf mortality rate in Mali, overall mortality rate 17% during the first year of life and total a 5% perinatal loss.
    (Khan 2007): Calf mortality rate in Peshawar city, 18% in one year.
    We assume an average 10% mortality rate for cattle bred in SSA.
    (Basumatary 2009): Mortality rate of pigs in eastern Himalayas, indigenous 6.05% and upgraded 5.64%.
    We assume an average 10% mortality rate for pigs bred in SSA.
    (Babiker 2009): Mortality rate in layer chicken flocks in traditional farms in Khartoum-Sudan, 25.08% between the age of day 0 and the end of week 16.
    We assume an average 25% mortality rate for birds bred in SSA.
    (Mukasa-Mugerwa, Lahlou-Kassi et al. 2000): Lamb mortality in Ethiopia, 1.6% stillborn and 41.8% died before reaching 1 year of age.
    We assume an average 33% mortality rate for sheep and goat bred in SSA.
    A weighted average for SSA agricultural production of cattle, pig, chicken, sheep and goat: 19%
22. *Mortality during transport to slaughter:*
    (Ibironke 2010): Mortality rate during transport to slaughter in Nigeria, cattle 0.10%.
    We assume an average 0.1% mortality rate during transport of cattle in SSA.
    (Appleby 2008): Mortality rate during transport to slaughter in Chile, pigs between 0.1-0.8%
    We assume an average 0.4% mortality rate during transport of pigs in SSA.
    (Ritz 2005): National mortality rate during transport to slaughter in the U.S: birds 0.35-0.37%
    (Petracci, Bianchi et al. 2006): Mortality rate during transport to slaughter in Italy: broilers 0.35%, turkeys 0.38% and spent hens 1.22%
    We assume an average 0.5% mortality rate during transport of birds to slaughter in SSA, due to warmer climate compared to Europe.
    (Knowles 1998): Mortality rate during transport to slaughter in South Africa, sheep 0.1%
    We assume an average 0.1% mortality rate during transport of sheep to slaughter in SSA.
    Rejection at slaughterhouse:
    (Alton, Pearl et al. 2010): Of 1 162 410 processed cattle in Ontario abattoirs, 6 875 carcasses were condemned (approximately 0.6%).
    We assume 0.3% of cattle and sheep are rejected at slaughter in SSA, half the amount rejected in the U.S.
    (Belk 2002): Of U.S. market hogs sent to slaughter, 0.2% were condemned (with 36% of the 0.2% due to dead-on-arrivals or dead-in-pens).
    We assume 0.06% of pigs are rejected at slaughter in SSA, half the amount rejected in the U.S.
    (Haslam 2008): Mean percentage rejected at UK slaughterhouse, broiler chickens 1.23%
    We assume 1.3% of birds are rejected at slaughter in SSA
    A weighted average for SSA mortality during transport to slaughter and rejection at slaughterhouse for cattle, pig, chicken, sheep and goat: 0.7%
23. (AWARENET 2003): European beef slaughtering: "trimming scraps" 0.7-3%, European pig slaughtering: "Others" 3-6%
    We assume similar losses in SSA
24. Assumption
25. Assumption
26. Estimated discard rate based on type of fishing gear used in the region. For information on how the estimations were made, see Annex 3 Discards as potential human consumption.
27. Assumption made from:
    (Nor 2004): The preparation and freezing of fish in developing countries is mainly done on land, some by-products are thrown away. Refrigerated transportation is often lacking or inadequate.
    (FAO 2009): Substantial postharvest losses occur in many developing countries due to a warm ambient climate combined with inadequate use of ice, long supply chains and poor infrastructure.
    A great proportion of African fisheries are small-scale fisheries.
    (FAO 2010): Postharvest weight losses in small-scale fishing are said to be particularly high. In SSA, investigations have suggested that losses may be around 5% while others suggest losses of between 10-20%. Average postharvest losses of about 15% of fish caught may be a reasonable assumption.
28. (Davies 2009): Losses during traditional fish processing in Nigeria, smoke-drying and brining-smoking 6-12%.

(FAO 2009): Smoking and fermentation are commonly used processing methods in the developing world.

29. Assumption made from:
    (Nor 2004): Refrigerated and well-functioning marketing system facilities are often lacking or inadequate in developing countries.
    (FAO 2009): Substantial postharvest losses occur in many developing countries due to a warm ambient climate combined with inadequate services in physical markets.
    (FAO 2010): Postharvest weight losses in small-scale fishing are said to be particularly high. In SSA, investigations have suggested that losses may be around 5% while others suggest losses of between 10-20%. Average postharvest losses of about 15% of fish caught may be a reasonable assumption.
30. Assumption
31. (FAO 2009): Milk losses in Uganda, 6% at farm
32. (FAO 2009): Milk losses in Uganda, 11% during spillage and spoilage during transport
33. (Tuszynski 1978): Wastage during packaging and transportation of milk is seldom less than 0.5%
34. (FAO 2009): Milk losses in Uganda, 10% at marketing
35. Assumption
36. (Huq 2002): Mortality rate of layer hens in a poultry farm in Bangladesh: 9% for unvaccinated birds and 4.5% for birds vaccinated against IBD and challenged with the IBD virus.
    We assume an average 8% mortality rate of layer hens in SSA.
37. Not included
38. Assumption
39. Assumption
40. Assumption

Table 37 Estimated/assumed waste percentages for each commodity group in each step of the food supply chain of North Africa, West & Central Asia; m=milling, f=fresh, p=processed

	Agricultural Production	Postharvest handling & storage	Processing & packaging	Distribution	Consumption
Cereals	6% [1]	8% [2]	2%(m), 7%(p)[3]	4% [4]	12% [5]
Roots & Tubers	6% [6]	10% [7]	12% [8]	4%(f), 2%(p)[9]	6%(f), 3%(p)[10]
Oilseeds & Pulses	15% [11]	6% [12]	8% [13]	2% [14]	2% [15]
Fruit & Veg	17% [16]	10% [17]	20% [18]	15%(f), 3%(p)[19]	12%(f), 1%(p)[20]
Meat	7.5% [21]	0.2% [22]	5% [23]	5% [24]	8% [25]
Fish & Seafood	6.6% [26]	5% [27]	9% [28]	10%(f), 5%(p)[29]	4%(f), 2%(p)[30]
Milk	3.5% [31]	6% [32]	2% [33]	8% [34]	2% [35]
Eggs	6% [1]	8% [2]	2%, 7% [3]	4% [4]	12% [5]

North Africa, West & Central Asia (NA,WA&CA):

1. (Smil 2004): Harvest losses in China, rice 7%.
   (FAO 2009): Harvest losses in Sierra Leone, rice 5%
2. (FAOSTAT 2010): Losses during transport, handling and storage of cereals between farm and distribution.
3. (UNIDO 2004): Typical losses during small-scale cereal milling, sorting grain 5-20%, hulling 5-15, packaging flour 2-10% and rejected flour 0-5%. We assume little waste during cereal milling in NA, WA&CA, an average of 2%.
   Typical losses during small-scale bread baking, batch preparation 2-5%, machine washing 2-5%, accidental product breakage 2-5% and rejected packages 2-5%.
4. Assumption
5. Assumption
6. (Hossain 2009): Average harvest losses in Bangladesh, potato 6%
   We assume similar potato harvest losses in NA,WA&CA
7. (FAOSTAT 2010): Losses during transport, handling and storage of roots and tubers between farm and distribution.
8. (UNIDO 2004): Typical losses during small-scale root crop processing, washing 0-5%, sorting 5-50%, slicing/dicing 5-10%, packaging 0-10% and rejection 0-5%.
9. (Kader 2009): Potato losses in Egypt, at wholesale market 2% and at retail market 1,4%
10. Assumption
11. (Castro-Garcia 2009): Damages on olives during harvest by hand, "bruise" 33% and "skin injury" 10%
12. (FAOSTAT 2010): Losses during transport, handling and storage of oil crops between farm and distribution.
13. Assumption
14. Assumption
15. Assumption
16. (Elyatem Undated): Losses during harvest in Northern Africa and Western Asia, fruit and vegetables 4-12%
    (Lustig 2004): Up to 25-30% of bananas produced in Costa Rica are dumped due to quality standards. Some are used for further processing but a large proportion is left to rotten in field. A lot of bananas and other fruit and vegetables are produced and exported in NA,WA&CA, e.g. Egypt. Losses were therefore assumed to occur in NA,WA&CA.
17. (FAOSTAT 2010): Losses during transport, handling and storage of fruit and vegetables between farm and distribution.
18. (UNIDO 2004): Typical losses during small-scale fruit and vegetable processing, washing 0-10%, sorting 5-50%, slicing/dicing 5-10%, accidental spillage 5-10% and rejected packs 2-5%.
19. (Elyatem Undated): Postharvest losses during marketing in some countries of the Near East and North Africa, fruit and vegetables 3-10%
    (Kader 2009): Physical losses of tomatoes in Egypt, wholesale market 5% and retail market 12%
20. Assumption
21. *Mortality during breeding:*
    (Wymann, Bonfoh et al. 2006): Calf mortality rate in Mali, overall mortality rate 17% during the first year of life and total a 5% perinatal loss.
    (Khan 2007): Calf mortality rate in Peshawar city, 18% in one year.
    We assume an average 10% mortality rate for cattle bred in NA,WA&CA.

(Basumatary 2009): Mortality rate of pigs in eastern Himalayas, indigenous 6.05% and upgraded 5.64%.
We assume an average 8% mortality rate for pigs bred in NA,WA&CA.
(Jabbar 2007): Mortality rate in two sampled meat production broiler farms 7% and 9%
We assume an average 8% mortality rate for birds bred in NA,WA&CA.
(Mukasa-Mugerwa, Lahlou-Kassi et al. 2000): Lamb mortality in Ethiopia, 1.6% stillborn and 41.8% died before reaching 1 year of age.
We assume an average 15% mortality rate for sheep and goat bred in NA,WA&CA.
A weighted average for NA,WA&CA agricultural production of cattle, pig, birds, sheep and goat: 7.5%

22. *Mortality during transport to slaughter:*
(Ibironke 2010): Mortality rate during transport to slaughter in Nigeria, cattle 0.10%.
We assume an average 0.1% mortality rate during transport of cattle in NA,WA&CA.
(Appleby 2008): Mortality rate during transport to slaughter in Chile, pigs between 0.1-0.8%
We assume an average 0.4% mortality rate during transport of pigs in NA,WA&CA.
(Ritz 2005): National mortality rate during transport to slaughter in the U.S: birds 0.35-0.37%
(Petracci, Bianchi et al. 2006): Mortality rate during transport to slaughter in Italy: broilers 0.35%, turkeys 0.38% and spent hens 1.22%
We assume an average 0.5% mortality rate during transport of birds to slaughter in NA,WA&CA, due to warmer climate compared to Europe.
(Knowles 1998): Mortality rate during transport to slaughter in South Africa, sheep 0.1%
We assume an average 0.1% mortality rate during transport of sheep to slaughter in SSA.
Rejection at slaughterhouse:
(Alton, Pearl et al. 2010): Of 1 162 410 processed cattle in Ontario abattoirs, 6 875 carcasses were condemned (approximately 0.6%).
We assume 0.3% of cattle and sheep are rejected at slaughter in NA,WA&CA, half the amount rejected in the U.S.
(Belk 2002): Of U.S. market hogs sent to slaughter 0.2% was condemned (with 36% of the 0.2% due to dead-on-arrivals or dead-in-pens).
We assume 0.06% of pigs are rejected at slaughter in NA,WA&CA, half the amount rejected in the U.S.
(Haslam 2008): Mean percentage rejected at UK slaughterhouse, broiler chickens 1.23%
We assume 1.3% of birds are rejected at slaughter in NA,WA&CA
A weighted average for NA,WA&CA mortality during transport to slaughter and rejection at slaughterhouse for cattle, pig, birds, sheep and goat: 0.2%
23. (AWARENET 2003): European beef slaughtering: "trimming scraps" 0.7-3%, European pig slaughtering: "Others" 3-6%
We assume similar losses in NA,WA&CA
24. Assumption
25. Assumption
26. Estimated discard rate based on type of fishing gear used in the region. For information on how the estimations were made, see Annex 3 Discards as potential human consumption.
27. Assumptions made from:
(Nor 2004): The preparation and freezing of fish in developing countries is mainly done on land, some by-products are thrown away. Refrigerated transportation is often lacking or inadequate.
(FAO 2009): Substantial postharvest losses occur in many developing countries due to a warm ambient climate combined with inadequate use of ice, long supply chains and poor infrastructure.
(Opara 2006): Fresh fish is highly susceptible to rapid deterioration after harvest, particularly in tropic conditions prevalent in e.g. Oman.
A great proportion of African and Asian fisheries are small-scale fisheries.
28. (Davies 2009): Losses during traditional fish processing in Nigeria, smoke-drying and brining-smoking 6-12%. Losses assumed similar in NA,WA&CA
(FAO 2009): Smoking and fermentation are commonly used processing methods in the developing world
29. Assumption
30. Assumption
31. (Hospido and Sonesson 2005): Assumed average milk losses caused by mastitis infection in dairy cows.
Mastitis (udder inflammation) affect up to 20-50% of dairy cows per lactation in European countries, precise data on incidence rate is not possible to give. Due to mastitis, milk is lost in the farm production due to decreased milk yield of the cow and due to discarded milk. Based on (Hospido and Sonesson 2005), we estimated the average milk production loss at 600 kg milk/dairy cow and case, and discarded milk at 200 kg milk/dairy cow and case. We assumed average incident rate to be 30%.

Milk lost due to mastitis is thus estimated at 800 kg * 0.3 = 240 kg/dairy cow and lactation (year). A normal milk yield in developed countries is 7500 kg/cow*yr (240/7500 = 3.2%). We used an average loss percentage of 3.5 % for milk in agricultural production which is based on the fact that mastitis is the most severe illness. We suggest that it is reasonable that these losses are in the range 2 – 5 % of milk production at the farm.
We assume similar losses in NA,WA&CA

32. Assumption
33. Assumption
34. Assumption
35. Assumption
36. (Huq 2002): Mortality rate of layer hens in a poultry farm in Bangladesh: 9% for unvaccinated birds and 4.5% for birds vaccinated against IBD and challenged with the IBD virus.
    We assume an average 8% mortality rate of layer hens in NA,WA&CA.
37. Not included
38. Assumption
39. Assumption
40. Assumption

Table 38 Estimated/assumed waste percentages for each commodity group in each step of the food supply chain of South & Southeast Asia; m=milling, f=fresh, p=processed

	Agricultural Production	Postharvest handling & storage	Processing & packaging	Distribution	Consumption
Cereals	6% [1]	7% [2]	3.5%(m), 3,5%(p) [3]	2% [4]	3% [5]
Roots & Tubers	6% [6]	19% [7]	10% [8]	11%(f), 8%(p) [9]	3%(f), 5%(p) [10]
Oilseeds & Pulses	7% [11]	12% [12]	8% [13]	2% [14]	1% [15]
Fruit & Veg	15% [16]	9% [17]	25% [18]	10%(f), 10%(p) [19]	7%(f), 1%(p) [20]
Meat	5.6% [21]	0.3% [22]	5% [23]	7% [24]	4% [25]
Fish & Seafood	8.2% [26]	6% [27]	9% [28]	15%(f), 10%(p) [29]	2%(f), 1%(p) [30]
Milk	3.5% [31]	6% [32]	2% [33]	10% [34]	1% [35]
Eggs	8% [36]	- [37]	0.1% [38]	3% [39]	2% [40]

South & Southeast Asia (S&SE Asia):

1. (Smil 2004): Harvest losses in China, rice 7%.
   (FAO 2009): Harvest losses in Sierra Leone, rice 5%
2. (FAOSTAT 2010): Losses during transport, handling and storage of cereals between farm and distribution.
3. (UNIDO 2004): Typical losses during small-scale cereal milling, sorting grain 5-20%, hulling 5-15, packaging flour 2-10% and rejected flour 0-5%.
   Typical losses during small-scale bread baking, batch preparation 2-5%, machine washing 2-5%, accidental product breakage 2-5% and rejected packages 2-5%.
4. Assumption
5. Assumption
6. (Hossain 2009): Average harvest losses in Bangladesh, potato 6%
7. (FAOSTAT 2010): Losses during transport, handling and storage of roots and tubers between farm and distribution.
8. (UNIDO 2004): Typical losses during small-scale root crop processing, washing 0-5%, sorting 5-50%, slicing/dicing 5-10%, packaging 0-10% and rejection 0-5%.
9. (Hossain 2009): Average losses of potato at traders' level in Bangladesh 10-12%
10. (Hossain 2009): Average losses of potato in consumer households and restaurants 3.2% and 4.5% respectively
11. (FAO 2010): Harvest losses in developing countries, soybean 4-7% and coconut 5-10%
12. (FAOSTAT 2010): Losses during transport, handling and storage of oil crops between farm and distribution.
13. Assumption
14. Assumption
15. Assumption
16. (Kitinoja 2010): Typical losses during harvest in India, Okra 2-5%, Tomato 4-5% and Mango 2-4%
    (Malik 2007): Proportion physically damaged Mango during harvesting in Pakistan 10%
    (Pal 2002): Losses during harvest in India, tomato 5%
    (Lustig 2004): Up to 25-30% of bananas produced in Costa Rica are dumped due to quality standards. Some are used for further processing but a large proportion is left to rotten in field. A lot of bananas and other fruit and vegetables are produced and exported in S&SE Asia, e.g. India. Losses were therefore assumed to occur in S&SE Asia.
17. (FAOSTAT 2010): Losses during transport, handling and storage of fruit and vegetables between farm and distribution.
18. (UNIDO 2004): Typical losses during small-scale fruit and vegetable processing, washing 0-10%, sorting 5-50%, slicing/dicing 5-10%, accidental spillage 5-10% and rejected packs 2-5%.
19. (Kitinoja 2010): Average physical losses (sorted out and not sold) for six fruit and vegetable crops in India, wholesale market 11% and retail market 10.2%
20. Assumption
21. *Mortality during breeding:*
    (Khan 2007): Calf mortality rate in Peshawar city, 18% in one year.
    We assume an average 10% mortality rate for cattle bred in S&SE Asia.
    (Basumatary 2009): Mortality rate of pigs in eastern Himalayas, indigenous 6.05% and upgraded 5.64%.
    We assume an average 6% mortality rate for pigs bred in S&SE Asia.
    (Jabbar 2007): Mortality rate in two sampled meat production broiler farms 7% and 9%
    We assume an average 8% mortality rate for birds bred in S&SE Asia.

(Mandal, Prasad et al. 2007): Lamb mortality in India, overall from birth to 1 year of age 12.6% while overall pre- and post-weaning mortality averaged 6.6% and 6.0% respectively
We assume an average 10% mortality for sheep and goat bred in S&SE Asia
A weighted average for S&SE Asian agricultural production of cattle, pig, birds, sheep and goat: 5.6%

22. *Mortality during transport to slaughter:*
(Ibironke 2010): Mortality rate during transport to slaughter in Nigeria, cattle 0.10%.
We assume an average 0.1% mortality rate during transport of cattle in S&SE Asia.
(Appleby 2008): Mortality rate during transport to slaughter in Chile, pigs between 0.1-0.8%
We assume an average 0.4% mortality rate during transport of pigs in S&SE Asia.
(Ritz 2005): National mortality rate during transport to slaughter in the U.S: birds 0.35-0.37%
(Petracci, Bianchi et al. 2006): Mortality rate during transport to slaughter in Italy: broilers 0.35%, turkeys 0.38% and spent hens 1.22%
We assume an average 0.5% mortality rate during transport of birds to slaughter in S&SE Asia, due to warmer climate compared to Europe.
(Knowles 1998): Mortality rate during transport to slaughter in South Africa, sheep 0.1%
We assume an average 0.1% mortality rate during transport of sheep to slaughter in S&SE Asia.
Rejection at slaughterhouse:
(Alton, Pearl et al. 2010): Of 1 162 410 processed cattle in Ontario abattoirs, 6 875 carcasses were condemned (approximately 0.6%).
We assume 0.3% of cattle and sheep are rejected at slaughter in S&SE Asia, half the amount rejected in the U.S.
(Belk 2002): Of U.S. market hogs sent to slaughter, 0.2% were condemned (with 36% of the 0.2% due to dead-on-arrivals or dead-in-pens).
We assume 0.06% of pigs are rejected at slaughter in S&SE Asia, half the amount rejected in the U.S.
(Haslam 2008): Mean percentage rejected at UK slaughterhouse, broiler chickens 1.23%
We assume 1.3% of birds are rejected at slaughter in S&SE Asia
A weighted average for S&SE Asia mortality during transport to slaughter and rejection at slaughterhouse for cattle, pig, chicken, sheep and goat: 0.3%
23. (AWARENET 2003): European beef slaughtering: “trimming scraps” 0.7-3%, European pig slaughtering: “Others” 3-6%
We assume similar losses in S&SE Asia
24. Assumption
25. Assumption
26. Estimated discard rate based on type of fishing gear used in the region. For information on how the estimations were made, see Annex 3 Discards as potential human consumption.
27. Assumption made from:
(Nor 2004): The preparation and freezing of fish in developing countries is mainly done on land, some by-products are thrown away. Refrigerated transportation is often lacking or inadequate.
(FAO 2009): Substantial postharvest losses occur in many developing countries due to a warm ambient climate combined with inadequate use of ice, long supply chains and poor infrastructure.
A great proportion of Asian fisheries are small-scale fisheries.
(Israel 2000): Estimated postharvest losses in the Philippines, fish 20-40%
28. (Davies 2009): Losses during traditional fish processing in Nigeria, smoke-drying and brining-smoking 6-12%. Similar losses were assumed in S&SE Asia.
(FAO 2009): Smoking and fermentation are commonly used processing methods in the developing world
29. Assumption made from:
(Nor 2004): Refrigerated and well-functioning marketing system facilities are often lacking or inadequate in developing countries.
(FAO 2009): Substantial postharvest losses occur in many developing countries due to a warm ambient climate combined with inadequate services in physical markets.
(FAO 2010): Postharvest weight losses in small-scale fishing are said to be particularly high.
(Israel 2000): Estimated postharvest losses in the Philippines, fish 20-40%
30. Assumption
31. (Hospido and Sonesson 2005): Assumed average milk losses caused by mastitis infection in dairy cows.
Mastitis (udder inflammation) affect up to 20-50% of dairy cows per lactation in European countries, precise data on incidence rate is not possible to give. Due to mastitis, milk is lost in the farm production due to decreased milk yield of the cow and due to discarded milk. Based on (Hospido and Sonesson 2005), we estimated the average milk production loss at 600 kg milk/dairy cow and case, and discarded milk at 200 kg milk/dairy cow and case. We assumed average incident rate to be 30%.

Milk lost due to mastitis is thus estimated at 800 kg * 0.3 = 240 kg/dairy cow and lactation (year). A normal milk yield in developed countries is 7500 kg/cow*yr (240/7500 = 3.2%). We used an average loss percentage of 3.5 % for milk in agricultural production which is based on the fact that mastitis is the most severe illness. We suggest that it is reasonable that these losses are in the range 2 – 5 % of milk production at the farm.
We assume similar losses in S&SE Asia

32. Assumption
33. (Tuszynski 1978): Wastage during packaging and transportation of milk is seldom less than 0.5%
    We assume losses of 2% during processing and packaging
34. Assumption
35. Assumption
36. (Huq 2002): Mortality rate of layer hens in a poultry farm in Bangladesh: 9% for unvaccinated birds and 4.5% for birds vaccinated against IBD and challenged with the IBD virus.
    We assume an average 8% mortality rate of layer hens in S&SE Asia.
37. Not included
38. Assumption
39. Assumption
40. Assumption

Table 39 Estimated/assumed waste percentages for each commodity group in each step of the food supply chain of Latin America; m=milling, f=fresh, p=processed

	Agricultural production	Postharvest handling & storage	Processing & packaging	Distribution	Consumption
Cereals	6% [1]	4% [2]	2%(m), 7%(p) [3]	4% [4]	10% [5]
Roots & Tubers	14% [6]	14% [7]	12% [8]	3%(f), 3%(p) [9]	4%(f), 2%(p) [10]
Oilseeds & Pulses	6% [11]	3% [12]	8% [13]	2% [14]	2% [15]
Fruit & Veg	20% [16]	10% [17]	20% [18]	12%(f), 2%(p) [19]	10%(f), 1%(p) [20]
Meat	5.6% [21]	1.1% [22]	5% [23]	5% [24]	6% [25]
Fish & Seafood	5.7% [26]	5% [27]	9% [28]	10%(f), 5%(p) [29]	4%(f), 2%(p) [30]
Milk	3.5% [31]	6% [32]	2% [33]	8% [34]	4% [35]
Eggs	6% [36]	- [37]	0.5% [38]	4% [39]	4% [40]

Latin America (LA):

1. (Smil 2004): Harvest losses in China, rice 7%.
   (FAO 2009): Harvest losses in Sierra Leone, rice 5%
2. (FAOSTAT 2010): Losses during transport, handling and storage of cereals between farm and distribution.
3. (UNIDO 2004): Typical losses during small-scale cereal milling, sorting grain 5-20%, hulling 5-15, packaging flour 2-10% and rejected flour 0-5%.
   Typical losses during small-scale bread baking, batch preparation 2-5%, machine washing 2-5%, accidental product breakage 2-5% and rejected packages 2-5%.
4. Assumption
5. Assumption
6. (FAO 2010): Typical harvest losses in Africa, cassava 14%
   We assume similar harvest losses of cassava in LA
7. (FAOSTAT 2010): Losses during transport, handling and storage of roots and tubers between farm and distribution.
8. (UNIDO 2004): Typical losses during small-scale root crop processing, washing 0-5%, sorting 5-50%, slicing/dicing 5-10%, packaging 0-10% and rejection 0-5%.
9. Assumption
10. Assumption
11. (FAO 2010): Harvest losses of soybeans 4-7%
12. (FAOSTAT 2010): Losses during transport, handling and storage of oil crops between farm and distribution.
13. Assumption
14. Assumption
15. Assumption
16. (Elyatem Undated): Losses during harvest in Northern Africa and Western Asia, fruit and vegetables 4-12%
    Harvest losses in LA were assumed similar to those in Northern Africa and Western Asia
    (Lustig 2004): Up to 25-30% of bananas produced in Costa Rica are dumped due to quality standards. Some are used for further processing but a large proportion is left to rotten in field.
17. (FAOSTAT 2010): Losses during transport, handling and storage of fruit and vegetables between farm and distribution.
18. (UNIDO 2004): Typical losses during small-scale fruit and vegetable processing, washing 0-10%, sorting 5-50%, slicing/dicing 5-10%, accidental spillage 5-10% and rejected packs 2-5%.
19. (Fehr 2001): Total waste of fruit and vegetables during marketing in Brazil, wholesale market 4% and retail market 12%
20. Assumption
21. *Mortality during breeding:*
    (Tokarnia, Döbereiner et al. 2002): Mortality rate in southern Brazil, cattle population 5%
    We assume an average 5% mortality rate for cattle bred in LA
    (Basumatary 2009): Mortality rate of pigs in eastern Himalayas, indigenous 6.05% and upgraded 5.64%.
    We assume an average 6% mortality rate for pigs bred in LA
    (Jabbar 2007): Mortality rate in two sampled meat production broiler farms 7% and 9%
    We assume an average 6% mortality rate for birds bred in LA.
    (Mandal, Prasad et al. 2007): Lamb mortality in India, overall from birth to 1 year of age 12.6% while overall pre- and post-weaning mortality averaged 6.6% and 6.0% respectively

We assume an average 10% mortality for sheep and goat bred in LA
A weighted average for LA agricultural production of cattle, pig, birds, sheep and goat: 5.6%

22. *Mortality during transport to slaughter:*
(Malena, Voslářová et al. 2007): Mortality rate during transport to slaughter in Czech Republic: excluded dairy cows 0.0396%, fattened cattle 0.0069% and fattened pigs 0.1075%
We assume an average 0.02% mortality rate during transport of cattle in LA.
(Appleby 2008): Mortality rate during transport to slaughter in Chile, pigs between 0.1-0.8%
We assume an average 0.4% mortality rate during transport of pigs in LA.
(Ritz 2005): National mortality rate during transport to slaughter in the U.S: birds 0.35-0.37%
(Petracci, Bianchi et al. 2006): Mortality rate during transport to slaughter in Italy: broilers 0.35%, turkeys 0.38% and spent hens 1.22%
We assume an average 0.5% mortality rate during transport of birds to slaughter in LA, due to warmer climate compared to Europe.
(Knowles 1998): Mortality rate during transport to slaughter in South Africa, sheep 0.1%
We assume an average 0.1% mortality rate during transport of sheep to slaughter in LA.
Rejection at slaughterhouse:
(Alton, Pearl et al. 2010): Of 1 162 410 processed cattle in Ontario abattoirs, 6 875 carcasses were condemned (approximately 0.6%).
We assume 0.6% of cattle and 0.3 % of sheep are rejected at slaughter in LA, half the amount rejected in the U.S.
(Belk 2002): Of U.S. market hogs sent to slaughter, 0.2% were condemned (with 36% of the 0.2% due to dead-on-arrivals or dead-in-pens).
We assume 0.06% of pigs are rejected at slaughter in LA, half the amount rejected in the U.S.
(Haslam 2008): Mean percentage rejected at UK slaughterhouse, broiler chickens 1.23%
We assume 1.3% of birds are rejected at slaughter in LA
A weighted average for LA mortality during transport to slaughter and rejection at slaughterhouse for cattle, pig, chicken, sheep and goat: 1.1%
23. Assumption
24. Assumption
25. Assumption
26. Estimated discard rate based on type of fishing gear used in the region. For information on how the estimations were made, see Annex 3 Discards as potential human consumption.
27. Assumption made from:
(Nor 2004): The preparation and freezing of fish in developing countries is mainly done on land, some by-products are thrown away. Refrigerated transportation is often lacking or inadequate.
(FAO 2009): Substantial postharvest losses occur in many developing countries due to a warm ambient climate combined with inadequate use of ice, long supply chains and poor infrastructure.
A great proportion of Latin American fisheries are small-scale fisheries.
28. (Davies 2009): Losses during traditional fish processing in Nigeria, smoke-drying and brining-smoking 6-12%. Similar losses were assumed in LA.
(FAO 2009): Smoking and fermentation are commonly used processing methods in the developing world
29. Assumption made from:
(Nor 2004): Refrigerated and well-functioning marketing system facilities are often lacking or inadequate in developing countries.
(FAO 2009): Substantial postharvest losses occur in many developing countries due to a warm ambient climate combined with inadequate services in physical markets.
(FAO 2010): Postharvest weight losses in small-scale fishing are said to be particularly high.
30. Assumption
31. (Hospido and Sonesson 2005): Assumed average milk losses caused by mastitis infection in dairy cows.
Mastitis (udder inflammation) affect up to 20-50% of dairy cows per lactation in European countries, precise data on incidence rate is not possible to give. Due to mastitis, milk is lost in the farm production due to decreased milk yield of the cow and due to discarded milk. Based on (Hospido and Sonesson 2005), we estimated the average milk production loss at 600 kg milk/dairy cow and case, and discarded milk at 200 kg milk/dairy cow and case. We assumed average incident rate to be 30%. Milk lost due to mastitis is thus estimated at 800 kg * 0.3 = 240 kg/dairy cow and lactation (year). A normal milk yield in developed countries is 7500 kg/cow*yr (240/7500 = 3.2%). We used an average loss percentage of 3.5 % for milk in agricultural production which is based on the fact that mastitis is the most severe illness. We suggest that it is reasonable that these losses are in the range 2 – 5 % of milk production at the farm.
We assume similar losses in LA
32. Assumption

33. (Tuszynski 1978): Wastage during packaging and transportation of milk is seldom less than 0.5%
    We assume losses of 2% during processing and packaging
34. Assumption
35. Assumption
36. (Huq 2002): Mortality rate of layer hens in a poultry farm in Bangladesh: 9% for unvaccinated birds and 4.5% for birds vaccinated against IBD and challenged with the IBD virus.
    We assume an average 6% mortality rate of layer hens in LA.
37. Not included
38. Assumption
39. Assumption
40. Assumption

Annex 2 Additional references for quantifying food losses/waste

"*Conversion factor*" determines the part of the agricultural product that is edible.

"*Allocation factor*" determines the part of the agricultural produce that is allocated for human consumption.

"*LIC*": low-income countries; "*MHIC*": medium/high income countries; "*FBS*": food balance sheets.

Cereals:
*Conversion factors: w*heat, rye = 0.78; maize, millet, sorghum = 0.79 (LIC), = 0.69 (MHIC); rice = 1; oats, barley, other cereals = 0.78. Source: (Wirsenius 2000)
Allocation factors for losses during agricultural production and postharvest handling and storage: Europe = 0.35; NA&Oce = 0.50; Ind. Asia = 0.60; SSA = 0.75; NA,WA&CA = 0.60; S&SE Asia = 0.67; LA = 0.40.

Roots & Tubers:
Proportion of roots and tubers utilized fresh:
Assumed average proportion of cassava utilized fresh in SSA = 50%. Source: (Westby 2002). In LA = 20%.Source: (Brabet 1998).
Assumed average proportion of potato utilized fresh in Europe and NA&Oce = 27%. Source: (USDA 2010). In NA,WA&CA = 81%. Source: (Potatoes_South_Africa 2010). In S&SE Asia = 90%. Source: (Pendey 2009) and (Keijbets 2008). In Ind. Asia = 85%. Source: (Keijbets 2008) and (FAO 2011).
Conversion factors: Peeling by hand = 0.74; Industrial peeling = 0.90. Source: (UNICEF 1990), (Mattsson 2001). Mean value = 0.82

Oil crops & pulses:
Allocation factors for losses during agricultural production and postharvest handling and storage: SSA = 0.63; NA,WA&CA = 0.12; S&SE Asia = 0.63; LA = 0.12 ; Europe = 0.20; NA&Oce = 0.17; Ind. Asia = 0.24. Source: (FAOSTAT 2010)

Fruit & Vegetables:
Proportion of fruit and vegetables utilized fresh:
Assumed average proportion of fruit & vegetables utilized fresh in SSA = 99%. Source: (Mungai 2000).
In NA,WA&CA = 50%. Source: (Guajardo 2008). In S&SE Asia = 95%. Source: (FAO Undated). In LA = 50%. Source: (Guajardo 2008). In Europe and NA&Oce = 40%. Source: (USDA 2010). In Ind. Asia = 96%. Source: (Cheng 2008)
Conversion factors: peeling by hand = 0.8; industrial peeling = 0.75; mean = 0.77. Source: own study and (UNIDO 2004)

Fish & Seafood:
Proportion of fish and seafood utilized fresh:
Assumed average proportion of fish & seafood utilized fresh in LIC = 60%; in MHIC = 4 %. Source: (FAO 2009)
Conversion factor: Average conversion factor for fish & seafood = 0.5. Source: (FAO 1989)

Annex 3 Discards as potential human consumption

Discards, the proportion of total catch that is returned to the sea (in most case dead, dying or badly damaged), represents a significant part of the world's marine catches and is generally considered a wasteful misuse of marine resources. The first global assessment was published 1994 and it stated a total discard of 27 million tonnes (Alverson 1994). The latest global study made by FAO in 2005 suggests that discard have dropped to 7.3 million tonnes but the figures are not totally comparable. Even if the first was overestimated and the latter underestimated, reductions are considered to be beyond doubt. The latest assessment corresponds to a weighted global discard ratio of 8%, however large variation among fishing gears and regions exists (Kelleher 2005).

Table 40 Total Discards (tonnes) (Kelleher 2005)

Summed landings for which discard information was available	78 448 399
FAO average marine nominal catch for 1992-2001 period (from Fishstat)	83 805 355
Weighted discard rate	8.0%
Total estimated discards (from discard database)	6 824 186
Extrapolated global annual discards for 1992-2001 period	7 290 170

Discard rates used

Discard rates per country is not separated sufficiently in the Kelleher report for a break down into the studied system of this report, therefore our approach have been to match gear used in the geographical regions in FAOSTAT with the relative performance of various gear in the Kelleher assessment. This is done mainly to distinguish the pelagic fisheries from the rest of the fisheries, since the pelagic fisheries have substantially lower discard rates than the global average and to a higher extend are used for oil and feed production. Alder et al. (2008) estimated that small pelagic fish make up 37% of the total capture fisheries landings, of which 90% is processed into fishmeal and fish oil and the rest is used directly as animal feed (Alder 2008).

Table 41 Discard performance per gear (tonnes) (Kelleher 2005)

Fishery	Landings	Discards	Weighted average discard rate *(%)*	Range of discard rates *(%)*
Shrimp trawl	1 126 267	1 865 064	62.3	0-96
Demersal finfish trawl	16 050 978	1 704 107	9.6	0.5-83
Tuna and HMS long-line	1 403 591	560 481	28.5	0-40
Mid-water (pelagic) trawl	4 133 203	147 126	3.4	0-56
Tuna purse seine	2 673 378	144 152	5.1	0.4-10
Multi-gear and multispecies	6 023 146	85 436	1.4	n.a.
Mobile trap/pot	240 551	72 472	23.2	0-61
Dredge	165 660	65 373	28.3	9-60
Small pelagics purse seine	3 882 885	48 852	1.2	0-27
Demersal long-line	581 560	47 257	7.5	0.5-57
Gillnet (surface/bottom/trammel)	3 350 299	29 004	0.5	0-66
Hand-line	155 211	3 149	2.0	0-7
Tuna pole and line	818 505	3 121	0.4	0-1
Hand collection	1 134 432	1 671	0.1	0-1
Squid jig	960 432	1 601	0.1	0-1

FAO food stat categories were generalized and grouped into four groups "Pelagic fish"; "Demersal fish"; "Other fish" and "Other non-fish". The groups were then matched with fishing gear from the Kelleher assessment, in broad terms based on the nature of fishery but verified by the amounts of landed mass in each gear segment.

Within each group (see grouping matrix in Table 42) a new weighted discard rate was calculated based on weights of the landings in the Kelleher assessment, and these new weighted group specific averages were finally applied to FAOSTAT from 2007.

Table 42 Grouping matrix FAOSTAT item and Kelleher gear specific discard rates

	FAOSTAT item	Production (ktonnes)	Share of total prod.	Kelleher Fishery Categories	Share of total land.	Landings (tonnes)	Discard rate	Weighted discard rate
Group 1	Pelagic Fish	37 124	34%	Mid-water (pelagic) trawl	9,7%	4 133 203	0,034	2,3%
				Small pelagics purse seine	9,1%	3 882 885	0,012	
Group 2	Demersal Fish	20 472	19%	Demersal finfish trawl	37,6%	16 050 978	0,096	9,5%
				Demersal long-line	1,4%	581 560	0,075	
Group 3 "Other fish"	Aquatic Products, Other + (Total)	16 780	15%	Tuna purse seine	6,3%	2 673 378	0,051	5,7%
	Marine Fish, Other	8 883	8%	Tuna and HMS long-line	3,3%	1 403 591	0,285	
				Gillnet (surface/bottom/trammel)	7,8%	3 350 299	0,05	
				Tuna pole and line	1,9%	818 505	0,04	
				Hand-line	0,4%	155 211	0,02	
				Multi-gear and multispecies	14,1%	6 023 146	0,014	
Group 4 "Other non-fish"	Molluscs, Other	15 907	15%	Dredge	0,4%	165 660	0,283	22,2%
	Crustaceans	10 318	9%	Shrimp trawl	2,6%	1 126 267	0,623	
	Cephalopods	4 060	4%	Mobile trap/pot	0,6%	240 551	0,232	
				Squid jig	2,2%	960 432	0,001	
				Hand collection	2,7%	1 134 432	0,001	
	TOTAL	109 484		TOTAL		42 700 098		

However, it should be noted that only half of the gear specific material in the Kelleher report could be attributed to a single fishery segment due to the nature of mixed fisheries, i.e. landings of 43 Mton displayed as gear specific compared with the nominal catch used in the report regarding 1992-2001 period at 93 Mton nominal catch. To compensate for this and errors occurring from grouping procedure a calibration factor was calculated based on the Kelleher assessment in relation to the output of this model during the same time period 1992-2001.

To summarize, this model of geographically specific discard only reveals differences between regions based on the gear that have been used given the gear rates used from the Kelleher report with data from 1992-2001. This procedure provided the estimation of the total discards per region 2007.

Edible part of discard

The total discard is not easily translated to an edible part of waste. Many discarded fish are not eaten by cultural preferences, but still they are potential protein source while others could be juveniles of otherwise targeted species or species typically eaten in other parts of the world. Also many types of fish could in theory be used for feed production, aimed for poultry or aquaculture. Morphological traits define the amount of bones and scales but the true species composition of all discards of the world are hard to assess and beyond the scope of this study.

Regarding the most common commercial species of the world however some generalizations can be made. The average yield in edible weight per wet weight of the 99 most important fish species is 55%, with a median value of 54% ranging from 36% to 67% percentage (FAO 1989).

In relation to the average commercial species it is reasonable to believe that the average discard, often consisting of juvenile species, should be lower than the average. However, without a suitable dataset we have assumed a conservative but arbitrary value of 0.5 yield factor for general discards. That is, we assumed that 50% of the mass discarded at sea could be used for human consumption.

Results

Table 43 Summarizing results.

Calibrated model	Discard rate, based on gear	Discard Mass (Mton)	Landings (Mton)
1 Europe incl. Russia	9,4%	1,11	9,72
2 Northern America & Oceania	11,9%	0,77	5,21
3 Industrialized Asia	13,8%	6,94	39,37
4 Sub-Saharan Africa	5,7%	0,23	3,51
5 Northern Africa, Western & Central Asia	6,6%	0,24	3,18
6 South- and Southeast Asia	8,2%	1,89	19,45
7 Latin America	5,7%	0,92	13,99
Calibration factor (from World 1992-2001)	0,92		

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